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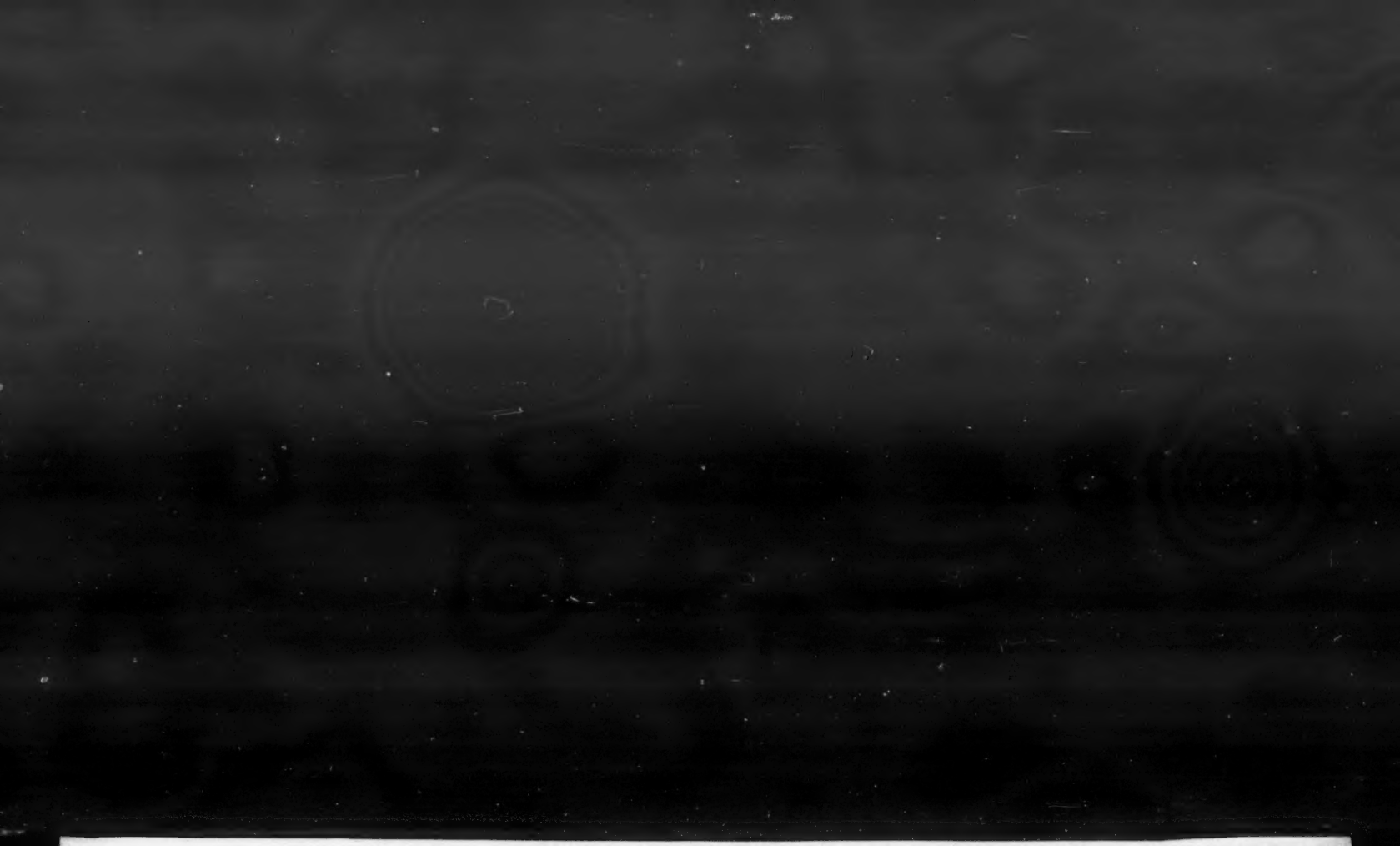


THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XV.—*Hot Water and Soft Glass in Their Thermodynamic Relations;* by C. BARUS.*

1. IT is my purpose in the present address to discuss the solvent action of hot water on ordinary glass, or indeed on any silicate. That these reactions occur abundantly in nature is well known; in the laboratory, however, they are as a rule, difficult to produce in such a way as to give an insight into the quantitative relations involved. About ten years ago, I made some curious experiments which seemed to give promise in this direction. I have recently repeated and extended them, carrying out the suggestions indicated on a larger scale and with entire success. I, therefore, take pleasure in communicating the results obtained, interpreted as a whole and from a somewhat broader point of view than was originally permitted.

Among natural silicates and in a scale of increasing acidity, we are apt to find the acid rocks less fusible than the basic rocks, and the aqueous fusion may be presumed to bear a definite relation to the igneous fusion. Thus, for instance, an obsidian which Prof. Iddings and I examined, fused aqueously at about 1250°, whereas the pumice resulting did not fully fuse until about 1650° was reached. Similarly an aqueous basic silicate, fusing at incipient redness, showed complete igneous fusion at about 1200°. The effect of composition will necessarily have to be deferred until the scope of experiments like the present has been worked out, but in a laboratory attack of the subject one is more apt to reach results with the fusible

* A lecture delivered before the Physical Society of the University of Göttingen.

soft glasses than with infusible hard glasses. In all cases, of course, the glass must be quite insoluble in water under ordinary conditions of temperature. In the present experiments I worked with the common glass containing lead, of the kind from which glass rods and thick tubes are usually made, and I was further induced to select it in order that the experiments on a larger scale might be made with the identical glass of my capillary tubes. In this way the results of the quantitative experiments on a smaller scale in glass tubes could be at once coördinated with the experiments in steel retorts.

2. In view of its amorphous structure and thermal properties, one is apt to look upon glass as colloidal, and it is expedient to examine at the outset in how far such a classification is tenable. Glass as a colloid must conform to the general relations of colloids and their solvents, and one must be able to predict certain peculiarities in the behavior of glass toward water. Colloids (1) at favorable temperatures swell up enormously in the presence of their solvents; (2) at higher temperatures the swollen coagulum goes over into clear and apparently thorough solution. In other words, the coagulum melts in its menstruum, mixes with it completely at a temperature which is probably characteristic for the colloid and, so far as known, remarkably independent of the solvent chosen.

It is essential, however, to have the solvent in the liquid state. These conditions are at once fulfilled for the case of starch, of gelatine and of pure rubber, seeing that in these instances the dissolving point of the colloid lies below the boiling point of the solvent. For vulcanized rubber this is, as a rule, not the case; the usual solvents, like carbon disulphide, ether, paraffine oils, chloroform, etc., boil away before the dissolving point (about 180°) of the colloid is reached. If, however, these volatile fluids be kept liquid under pressure up to 185°, vulcanized rubber passes into clear solution as easily as starch. Still other colloids, like wood, decompose, i. e., undergo destructive distillation even when submerged in the solvent (water) under pressure, below the dissolving point.

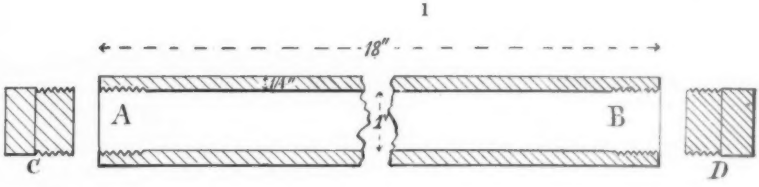
I shall show that ordinary glass fulfills the above conditions perfectly; but before doing so a brief description of the experiments with retorts is advisable.

3. If water be selected as a suitable colloidal solvent of glass, the dissolving point will certainly lie above the boiling point of the liquid. Hence it is necessary to make use of high pressure retorts; and I shall take the liberty of describing a simple and efficient form which has served me not only in the present but in many similar experiments.

In the figure (1) AB is a piece of seamless drawn steel tubing obtained from John S. Leng, New York, about 45^{cm} long

and 2·5^{cm} in diameter, with walls ·6^{cm} thick. The interior is threaded (12 to inch) at the ends, and screw plugs are provided fitting the threads snugly (*CD*).

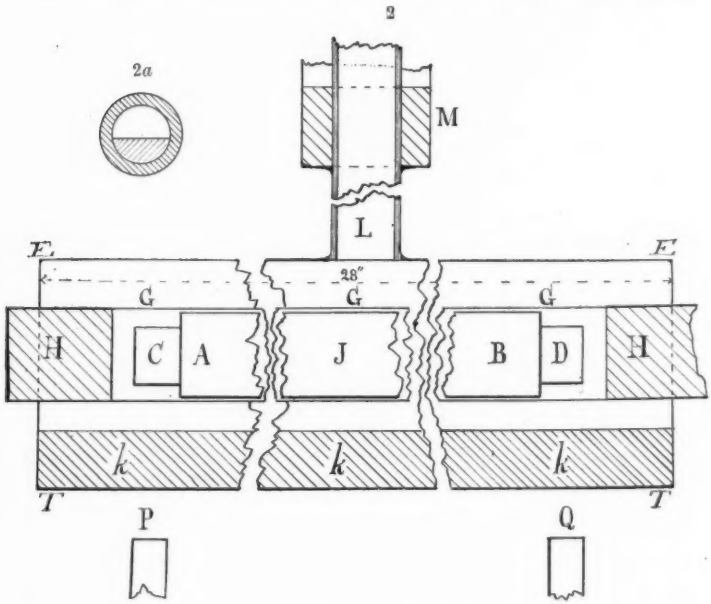
In order to secure a gas-tight joint for temperatures below 150°, each of the plugs is covered with a thin layer of solder in the usual way, by dipping it first in soldering salts, and then in melted solder. For temperatures below 250°, a layer of lead is applied in the same way. For temperatures above this a layer of zinc, and at red heat a layer of copper answers less satisfactorily. The copper coating is put on by dipping the hot plug in borax and then in a crucible of melted copper.



Unfortunately the copper is hardened by this process and I have only been able to use the screw for small diameters. Solder adheres most perfectly and less stress is needed in forcing the screw plug home. Lead, in spite of its greater softness, offers much more viscous resistance during this operation; a noteworthy result. Tubes continually used in this way are at length liable to split longitudinally, but after several hundred experiments per tube I have only had one accident of this kind. The thread is apt to suffer serious wear and tear before the tube gives out. The joint obtained as above is apparently quite gas-tight, and I have frequently heated carbon disulphide above 200° for hours, without appreciable loss. Nor is it necessary to use all the threads at once; a fresh insertion of two complete threads usually suffices, so that the screw bolt lasts throughout several experiments before requiring to be recovered. Pressures above 1000 atm. were applied without leakage.

To heat the tube to a given constant temperature, vapor baths of the form fig. 2 are available. This consists of a cylinder *ET*, 10^{cm} in diameter, 70^{cm} long, closed at the ends, except for the axially perforating eccentric cylinder *GG*. The latter is large enough to receive the retort *AJB*, snugly, and asbestos plugs, *HH*, guard against loss of heat at the ends. The vapor bath is made of sheet iron brazed together. The liquid to be boiled, *k*, is charged into the bottom of the outer cylinder, and vapors escape by a lateral vent of gas pipe

($\frac{3}{4}$ inch), *L*. By surrounding this at about two feet from the boiler with a narrow cylinder containing water, *M*, the vapors are usually condensed and flow back without giving annoyance. In the present experiments, the liquid, *k*, was naphthaline boiling at 210° and the vapor bath needed no special attention for months. If the bath is well enveloped with asbestos, except at the two patches on the bottom where the flames of two ordinary Bunsen burners, *P*, *Q*, impinge against free



metal, these are quite sufficient to maintain continuous ebullition at 210° for an indefinite time. It is well to keep *M* supplied with water by aid of some automatic dropping arrangement.

4. The charge of laboratory glass specified, being the broken capillary tubes of earlier correlative experiments, pulverized and sifted to a fine granular powder, was introduced into the retort with water. About 210 grams of glass and 50 grams of water was known to be a promising ratio. The retort was then put into the vapor bath and kept at 210° for about 12 hours.

On opening the cold retort the glass was found to be quite fused down to a resinous, opalescent, very hard and tough

body, containing white inclusions of partially converted water glass, but otherwise homogeneous. About 240 grams were removed from the retort, to which the glass adhered so firmly that a cold chisel and hammer were necessary for the process. Looking through the retort endwise, it was seen to be about one-half filled and the top surface of the glass smooth, as shown in fig. 2*a*. No excess of water was apparent, all having been absorbed. Surfaces of the glass broken from the retort were black with iron oxide.

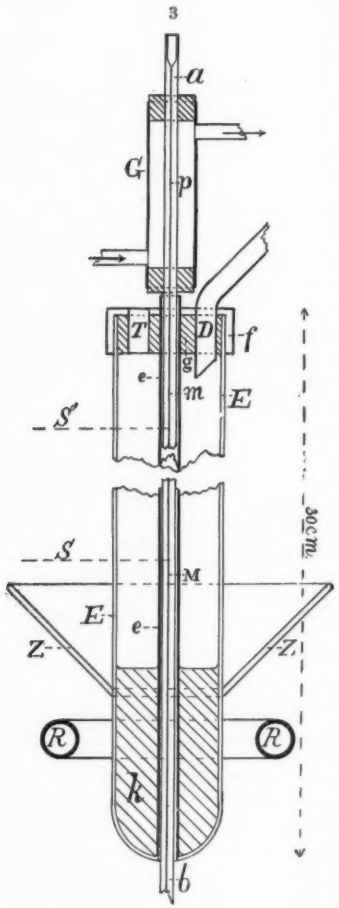
Heated in the air above a candle flame the glass melts, swells up enormously with loss of water to a silvery white pithlike pumice. The experiment recalls the behavior of a pharaoh serpent, but is not quite so striking. On igneous fusion at red heat, the usual black lead glass is again obtained. As to hardness, water glass is not much inferior to the original igneous glass. When clear it has a different refractive index and a different density.

After exposure to the air water glass gradually disintegrates. Even after a few weeks cracks permeate the mass, and the originally solid tough block may easily be broken across. I have supposed that the combination of water and glass, stable under pressure at 210°, is unstable at ordinary temperatures, and that water set free under probably immense pressures is the cause of this phenomenon. Inasmuch as the fragments retain their property of swelling on fusion unimpaired, it is much more probable that the real cause of breakage is the gradual reaction of internal stress.

Not all kinds of glass succumb to the present treatment at 210°. The more infusible glasses are much less easily soluble. Many experiments of the present kind made with hard glass showed absolutely no cohesion or fusion when examined in the cold, even after 18 hours of exposure. Hence a higher temperature than 200° will here be needed, and the case is emphatically true for quartz. Coördinating the present experiments, in which a phenomenally low dissolving temperature is evidenced, with the results obtained from natural silicates, it is clear that every glass at a sufficiently high temperature must eventually show complete solubility in water.

Having obtained the water glass in the above form, I next endeavored, with the addition of more water, to obtain the glass in the liquid state at ordinary temperatures; but these experiments signally failed. About 180 grams of the given water glass were triturated, mixed with 50 grams of water, charged in the retort and heated for 14 hours to 210°. On opening about $10^{\text{cub cm}}$ of viscous soapy black water were taken out, floating above a black scum of glass. The substance when dry was friable and had lost the property of fusing with swell-

ing. Black stalactites, however, were seen in the tube and the edges were everywhere rounded, indicating fusion. The result of the experiment was a thorough dissociation of the charge, giving impure water and an insoluble residue of silicate. This mass was again pulverized, charged into the retort and heated for five hours. On opening the cold retort about 100$^{\text{cub cm}}$ of black soapy water were removed; the glass remained black and non-coherent. Excess of water does not, therefore, favor the present reactions.



5. With these definite results in hand, we may next endeavor to inquire into the quantitative nature of the present phenomena. Having this end in view I returned to the experiments described in this Journal (vol. xli, 1891) some years ago with the new results incorporated in the present summary. To make the account intelligible it will be expedient to give a sketch of the apparatus used, the essentials of which are shown in fig. 3. Here *ab* is the capillary tube, to be cemented below into the steel flange for insertion in the compression pump. The capillary tube contains a thread of water *SS'* (lines of sight of an external cathetometer), between visible threads of mercury *m*, *M*, of which the upper one is sealed in position by a terminal thread *p*, of solid paraffine, kept cold by the jacket of circulating water, *G*. The lower mercury thread, *M*, transmits the pressure of the force pump to the water, which is thus made to react on the inner wall of the capillary tube at a definite pressure and temperature. The latter is secured by a boiling tube *EE*, of clear glass, of the kind frequently described

in my work, consisting of two concentric glass tubes, E, e, joined at the ends, the inner snugly enveloping the capillary tube ab. Tubulure T holds a thermometer. Tubulure D leads to the condenser, which for a charge of naphthaline at k (heated by the ringburner R and screen Z) is merely a long tube. Cooling in air is sufficient and the operation continuous. In experiments like the present it is convenient to join the concentric tubes E and e above, by a gas pipe cap f, cemented to the glass with plaster of Paris g. Asbestos jackets envelop the tube E except at the longitudinal fissures cut into them for observation. After the liquid k boils, the temperature of the column of vapor between the plane of ebullition and of condensation, both distinctly apparent, is constant. It is thus merely necessary to chase the latter into the condenser to obtain constancy along SS'.

With well annealed capillary tubes, $\cdot 02^{cm}$ to $\cdot 05^{cm}$ in diameter internally, and $\cdot 6^{cm}$ in diameter externally, pressures from 400 to 600 atms. are admissible. With diameters increased by water solution from $\cdot 04$ to $\cdot 07^{cms}$ (often three times), the pressure limits are reduced; less, however, by change of diameter than by the continued stress to which the tube has been subjected.

The phenomena to be observed during the action of hot water on glass may be described as follows: During heating the thread of water expands thermally, but the expansion is partial; before the constant temperature 210° is reached the thread has begun to contract in marked degree in consequence of the corrosion. The full thread length for 210° is not reached.

The reaction itself will appear differently according as it takes place slightly below or slightly above the solution temperature. At 185° the water glass obtained is rather a coagulum. The solid swells enormously under the absorption of water, like any other colloid. It is apt to remain white and turbid, so that the progress of the mercury meniscus is seen with difficulty through the semi-translucent thread. The water glass remains elastic, i. e., it contracts and expands under the influence of pressure. Compressibility slowly but regularly increases. Contraction of the combined volume of glass and water progresses at an accelerated rate. If after long reaction (1 hour), the cold capillary be broken across and examined under the microscope, the capillary canal is found to be nearly full of an agate-like warty solid accretion. This is water glass in the swollen coagulated state.

At 210°, however, the solution temperature is exceeded. The preceding phenomenon of swelling passes rapidly into the present phenomenon of solution. The water glass gradually

becomes clear, the mercury meniscus glistens brilliantly, the thread breaks into shining globules. The white coagulum clarifies from the periphery inward toward the axis of the tube, where it gradually vanishes. Compressibility at first increasing with great rapidity to an enormous value, falls off, as it were, suddenly to the relatively low value attributable to hot water. While the reaction proceeds the solution is inelastic, i. e., the liquid fails to expand on removal of pressure. Volume decrement is at first extremely rapid, finally to vanish asymptotically in the lapse of time. The tube seen through the telescope shows an internal current continually flowing from the bottom to the top, and this current persists until the reaction terminates in clearness of tube and saturated water glass. The effect of pressure here is thus virtually an acceleration of the velocity of the current, and hence compressibility may be rated at any large value whatever, since the additional velocity imparted by pressure is now dependent on the viscosity of the flowing liquid. For this reason, moreover, removal of pressure produces breakage of thread and cavities in the viscous silicate, which in their turn swim along in the upgoing current. Cavities and mercury globules retain their relative positions to each other during the motion, though the former may often be brought to vanish by excess of pressure. I have inferred from this that the column of water glass, now two to three times the original diameter of the capillary thread of water, moves as a whole and not telescopically at a decreasing rate from the axis outward: the latter case would imply a deformation of the mercury globules which has not been observed. The mercury threads approximately retain their original diameter.

7. To obtain a clear view of the progress of the reactions here in question, the annexed chart of a typical case may be consulted, in which volumes (thread lengths in cms.) and compressibilities are laid off vertically, and the corresponding time of exposure dated from the beginning of heating, horizontally. It will be seen that 20 minutes after beginning the boiling (less than 10 minutes of exposure to 210°) the hot thread has contracted to the length of the original cold thread, and that contraction proceeds enormously beyond this. The total volume contraction of the system water and glass, as taken from the chart, would be over 30 per cent of the cold length. The observed changes of compressibility would be from about $100/10^6$ per atm., for nearly pure water, to something like $600/10^6$ for dissolving water glass. The diameter of the capillary increased from $\cdot 024^{cm}$ (water), to $\cdot 071^{cm}$ (water glass), upwards three times. These data were found from measurements made on sections of the cold tubes. Cf. fig. 5.

How differently a thread of paraffine behaves in a like tube at 20° and under the same conditions, is seen in the attached curve of the chart. Volume is here a slightly increasing quantity in the lapse of time, a result doubtless due to gradually increasing temperature of the vapor bath. The two phenomena are totally dissimilar. So also as I showed elsewhere, the errors of measurement introduced by the elasticity and the viscosity of the glass tube are of insignificant values as compared with the enormous compressibilities of the present investigation.

To what degree the compressibilities are real may be tested during the slower of the above reactions, at 185°, when the liquid is elastic. The compressibilities per atm. in millionths of the normal volume at the outset of the experiment were

20 to 100 atm.	100 to 200 atm.	200 to 300 atm.	300 to 400 atm.
146	144	142	146
and 15 minutes later			
188	176	201	189

the observations being throughout reliable.

At 210° the rate of reaction is far too rapid to yield results of anything like this degree of precision. A conception of the remarkably large results obtained may be secured by recalling that water and glass with compressibilities of about $100/10^6$ and $3/10^6$ at 210°, during the process of reaction show values which can only be compared with so mobile a body as liquid ether, between 100 and 200 atm. Compressing ether to keep it liquid the approximate data for compressibility are

29°	65°	100°	185°
156	207	305	741

millionths per atm., of which the two last values only are large enough to compare with the data for water glass. Yet the latter solidifies at ordinary temperatures to a hard solid, quite glassy in character.

8. The clear coagulum obtained after the reaction has subsided is again elastic, but its compressibility of minimum value probably less than that of water at 210°. Compression is accompanied with evidences of rigidity and the density of the system is a maximum. Currents have ceased. On cooling, bubbles appear in the clear column of water glass, originating at points in the axis, and growing thence centrifugally outward. The volumes in which the mercury globules were snugly imbedded at 210° now increase, until the cavity is but partially filled. As much as $\frac{1}{3}$ of an ovoid cavity may be empty. All of this points to marked contraction on solidification and cooling. The old capillaries, however carefully protected or slowly cooled, invariably break throughout their length in the lapse

of time. On casual inspection one might ascribe this result to an expansion of the solidifying core: but the occurrence of the bubbles mentioned, which open out with the great rapidity attributable only to solidification, and the fact that breakage (cf. fig. 5, *b*) is often only confined to the water glass core (being a longitudinal fissure within this, not extending to the igneous glass envelope), show that an intense strain of dilata-

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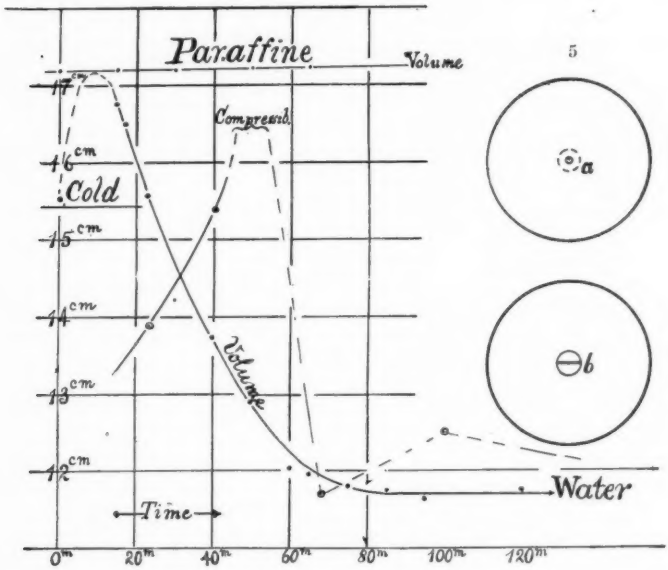

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tion is encountered. All observations indicate contraction with large volume-coëfficient, too large for the igneous glass to follow. Some rough measurements of the coëfficient of expansion, the best available under the circumstances, gave between 25° and 185° a coëfficient ·0020. The mean coëfficient of water within these limits would be but ·0008. Something of this order must obtain if within a capillary section and a moderate interval of temperature, tensile stresses sufficient to rupture the tube are to be developed on cooling. But the bubbles and stresses thus resemble the occurrences which in Prince Rupert drops require so much higher a temperature to produce them.

Special mention may here again be given to the acceleration of the rate of reaction with increasing temperature. At 185° there is mainly swelling and absorption. At 210° the reaction

is already too rapid to admit of the physical measurement of its successive stages.

9. The appearance of the cold tube when cut across is enlarged in figure 5 (with fig. 4, p. 170), which shows the external and the original internal diameters, and the diameter of the core of water glass (the latter dotted). Apart from the bubbles usually connected by a very fine capillary canal, the tube has become a glass stem. On holding the tube in a suitable position, the core of water glass may be seen sharply dif ferentiated from the igneous envelope. In other respects there is firm coherence, and the water glass appears on trial about as hard as the igneous glass. Slight heating melts the water glass, which then swells up enormously and exudes from the tube, like pith.

10. An experiment was made to test the colloidal character of the reaction by replacing the thread of water with a thread of solution of cobalt nitrate. Should the latter turn blue at 210° the occurrence of chemical reaction would be indicated. Not only was this not the case, but the reaction completing itself in the usual way, left a gray granular scum of decomposed cobalt salt in the axis of the tube. Hence all water enters the glass by diffusion, the glass itself performing the function of a *semi-permiable membrane* of the energetic character specified.

Yet the reaction as a whole cannot be represented as a mere physical diffusion: for it is not probable that the reduction of the concentration gradient from the axis of the tube outward, could result in so sharp a differentiation of water glass core and igneous glass envelope as is observed. Nor am I aware that the occurrence of contraction in a system undergoing colloidal solution, has been definitely observed or is the usual rule. Saturation is to some extent given by the swollen solid coagulate only; it is not usually observed in the colloidal solution above the melting point. In the case of water glass a definite condition of saturation at the close of the reaction must be inferred. The results above obtained with retorts in which definite quantities of water were needed to yield a clear glass, are to the point.

Since glass at ordinary temperatures does not swell up in the presence of water, the question suggests itself whether all colloids at temperatures sufficiently below their dissolving points will lose the property of swelling.

If the colloid be regarded as consisting of aggregated molecules, with all particles of nearly the same specific size but larger than the molecular diameter, the following graphic exhibit of the phenomenon of solution and coagulation is tenable. The three groups of forces involved, viz., the attraction of liquid molecules for each other, of solid molecules for each

other, and the attraction of solid and liquid molecules may be symbolized by FF, SS, and FS, respectively. Of these groups $FF+SS$ together promote precipitation or crystallization, while FS alone is favorable to solution. The former case occurs for $FF+SS>FS$; the latter for $FF+SS<FS$. $FF+SS=FS$ for a given diameter of particle is the stable case. Suppose

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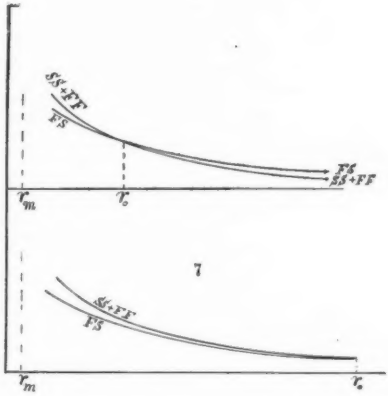

now the diameter of the particle is laid off horizontally, and the forces in question are laid off vertically. We obtain two curves which must intersect and have the relations to each other given by the figure, if a definite diameter $2r_o$ larger than the molecular diameter $2r_m$ is to be stable. For larger particles the forces FS are in excess and the particle will dwindle by solution. For smaller particles the forces $FF+SS$ are in excess, and the particle will grow by accretion. The effect of temperature is to shift the curves relatively to each other, temperature increase tending to raise SF and to lower $FF+SS$, simultaneously. Recalling the colloidal condition $r_o>r_m$, the result is a motion of the point of intersection to the left and an approach of the r_o to the molecular diameter. Temperature decrease has the reverse effect, moving the point of intersection to the right. It is then merely necessary to suppose the two curves to have very nearly the same slope beyond r_o, to bring about an enormous increase in the diameter of the colloidal particle $2r_m$, for very slight thermal shifting. This is illustrated in fig. 7, and is the most natural conception I can form of coagulation. If the mass is very viscous, the condition of equilibrium will rarely be approached but very slowly. Separately considered, the curves assert that with increasing size of

particle or number of molecules to the aggregate, the attractions of particles for each other and for the liquid decrease. The nature of these forces is thus a residual affinity.

12 If again we turn to the chart, fig. 4, and inquire what will be the shape of the isotherm in a *pv* diagram, we observe that the reaction begins with the small compressibilities (large bulk modulus) of pure water, then passes through enormous values of compressibility back again to the extremely small values of compressibity at the end of the reaction. The isothermal is therefore a doubly inflected curve of the form, fig. 8, well known in the treatment of vapors. To every point of the present curve, however, there corresponds a definite concentration of water glass, increasing from right to left. The curve begins with compositions of much water and little glass, with stable solutions and elastic fluids; whatever water is forced into the glass corpuscles by pressure, comes freely and almost wholly out again when pressure is relieved. The curve terminates in compositions of much glass and little water, again stable and elastic; the intermediate field, *a*, being unstable and inelastic (non-resilient). In view of the exceedingly viscous liquids involved, the reactions are not implosive but can be observed through, from liquid water to semi-solid water glass, including the unstable part of the curve. Looking at these reactions from another point of view, they present a striking analogy to *mass action* in which either the water or the water glass is stable according as an excess of one or the other of the ingredients, water and glass, is encountered. The same inference follows from the experiments (§ 3) made in steel retorts. We have therefore traced a peculiar case of mass action evidenced by the successive values of the compressibility of the solution.

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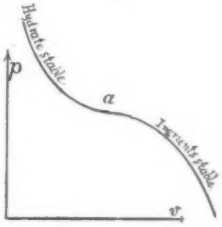

13. In the above paragraphs, I have endeavored to show that while glass expands in absorbing water, the system glass-water contracts 20 per cent to 30 per cent, so far as can be discerned. The important question thus at once arises, whether so large a contraction as this can be supposed to occur without the evolution of heat. It seems to me that this is quite improbable, although I have not been able, after some pains, to complete a direct test in answer to the inquiry. Under high pressure conditions such experiments are so difficult, however, that the failure to obtain direct results is not surprising: for in view of the necessarily small lateral dimensions of high pressure apparatus, and the relatively slow reaction, etc., the investigation of

the thermal data sought is almost bound to prove futile. There is so little opportunity favoring the accumulation of heat.

In nature, where a large extent of rock is liable to be placed under the influence of water at high temperatures, the conditions are much better adapted to promote solution. Let it be called to mind that the rate of reaction increases rapidly with increasing temperature, i. e., with increasing depth below the surface of the earth. Furthermore, that whatever heat is produced by the reaction itself, will in its turn additionally stimulate its intensity. Hence it is altogether probable that at sufficient depths within the earth, the heat evolved by the action of water on rock will be generated faster than it can be dissipated. The result would be a subterranean, local source of heat whose efficiency is variable with the character of the rock, the topography of the surface, the temperature and depth of the available mass of water, etc. If we endeavor to associate volcanic action with some such agency as here sketched, we should agree that the occurrence of volcanoes at the sea-shores presents the case of greater probability, while inland volcanoes are not excluded. The probability would increase for those rarer cases in which the necessary quantity of water is in any accidental way liable to reach the quantity and special kind of rock in question. Even under suitable conditions of temperature therefore, and near the ocean, active volcanoes would be a rare occurrence, seeing that the particular ingredients needed for an intense reaction are not everywhere available. Nor is it necessary that the material ejected by the volcano be the identical rock acted on, since in the above experiments with retorts, dissociations are already in evidence. The material which ultimately remains hydrated will depend on other reactions and segregations, possible after termination of the hydration, or upon reactions within the hydrated magma.

Finally with the completed hydration of the given silicate in the manner evidenced by the above experiments with capillary tubes; in other words, after the available water or rock have been used up, the reaction would definitely subside and the volcano become extinct.

It is not necessary to trespass speculatively as far as I have done in the preceding paragraph to detect the definite bearing of the present results on the potential fluidity of magmas, their diminished density, etc. I will give a rough sketch of the geologic conditions involved to make my meaning clearer. *A* represents a vertical section of the ocean with the depths laid off in kilometers. As the water put into reaction must remain liquid at least up to 200° (say), the water available for the reaction must be tapped from a level deeper than 150 meters, or roughly

200 meters below the surface of the ocean. Otherwise the water would be vaporized and inactive. This depth is marked *dd* in the diagram to show its relation to the surrounding ocean and shore lines.

B, in the diagram, represents the adjoining land, with the isotherms higher than 200° located in place. The newest measurements put these about 400 kilometers apart per 100°

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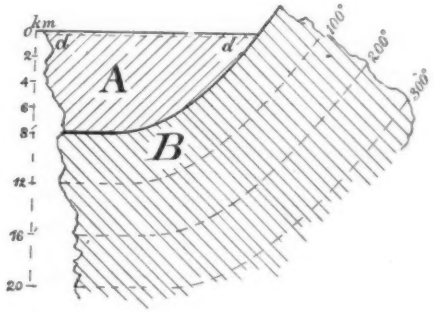

C. If therefore water from anywhere below the level *dd* enters the rock by whatever catastrophe, penetrating as far as the isotherm for 200°, the rock there, if of the character of the above experiments, will become liquified, apart from pressure. The hydrated silicate in place is thus virtually fluid below the contours of the isotherm 8 kilometers below the surface. Thus the depth of the isotherm of potential fusion is placed about five times as near the surface as would be the case for the corresponding igneous fusion. Estimating the pressure on the 210° isotherm as much below 3000 atmospheres, the whole phenomenon is in an interesting way placed within laboratory reach.

Brown University. Providence, R. I.

Art. XVI.—*Conrad's Types of Syrian Fossils;* by C. E. Beecher.

In the official report of the United States Expedition to the Dead Sea and the River Jordan, by Lieut. W. F. Lynch, U. S. N., published in 1852,* there is a chapter (pp. 209–229) by T. A. Conrad, containing a "Description of the Fossils of Syria collected in the Palestine Expedition," accompanied by an appendix (pp. 230–235) and illustrated by thirty lithographic plates.

It appears from the context that the collections studied by Conrad were from three separate sources: (1) Material obtained by Dr. H. J. Anderson, in charge of the geology of the Lynch expedition; (2) specimens furnished by the Friends of Missions, a society in Cincinnati, Ohio; and (3) specimens loaned by Professor Silliman from the Geological Cabinet of Yale College.

Professor R. P. Whitfield in a paper on Syrian fossils, published in 1891,† makes the following statement regarding these collections (l. c., p. 383, footnote): "I have made every reasonable effort to find the originals of Mr. T. A. Conrad's species described in the Official Rept. of the U. S. Exped. to the Dead Sea and River Jordan, under Lieut. W. F. Lynch, for the purpose of identification and comparison as well as verification; they seem, however, to have been entirely lost sight of, as inquiries of the different societies and persons having charge of collections, where they might have been deposited, have entirely failed to bring any of them to light."

It is, therefore, a matter of some scientific importance to be able to announce in this notice, that in the course of the unpacking, classification, and redistributing of the material belonging to the Geological Department of the Yale University Museum, now in progress, a box has been found containing a number of Conrad's types of Syrian fossils. The box label reads: "Fossils of Palestine described in Lt. Lynch's Report by Dr. Anderson, Sept. 1852." The specimen labels are written in Conrad's handwriting and have torn edges, a method of labelling quite characteristic of that author.

In order to define clearly the precise value of this material as a collection of types, the terminology proposed by Schuchert‡

* Official Report of the United States Expedition to explore the Dead Sea and the River Jordan. By Lieut. W. F. Lynch, U. S. N. 4to, pp. 236, plates 1–22 and 1–8 in Appendix. Baltimore, 1852.

† Observations on some Cretaceous Fossils from the Beyrût District of Syria, in the Collection of the American Museum of Natural History, with Descriptions of Some New Species. By R. P. Whitfield. Bulletin of the American Museum of Natural History, vol. iii, No. 2. 1891.

‡ What is a Type in Natural History? Science, N. S., vol. v, No. 121, 1897.

is followed, and a catalogue of the specimens is herewith appended.

Types of Syrian Fossils described by T. A. Conrad in Lt. Lynch's Expedition to the Dead Sea, 1852, in the collections of Yale University Museum.

Holotypes.

No. (Number in parenthesis = original number).

1 (22) *Mactra pervetus* Conrad. (l. c.) Plate 8, fig. 49. 1 specimen.
2 (35) *Holaster syriacus* Conrad. Plate 1, fig. 2. 1 specimen.
3 (71) *Lucina syriaca* Conrad. Plate 10, fig. 57. 1 specimen.
4 *Nerinea syriaca* Conrad. Plate 12, fig. 72. 1 specimen.

Cotypes.

5 (10) *Cardium biseriatum* Conrad. 1 specimen.
6 *Cardium biseriatum* Conrad. Plate 6, fig. 39. 1 specimen.
7 (16) *Tellina syriaca* Conrad. (No. 16 figured.) Plate 10, fig. 61. 4 specimens.
8 (23) *Tellina syriaca* Conrad. Plate 10, fig. 60. 1 specimen.
9 *Echinus syriacus* Conrad. Plate 1, fig. 1. 1 specimen.

Paratypes.

10 (1, 3) *Chenopus syriacus* Conrad. 2 specimens.
11 (2, 4) *Natica indurata?* Conrad. 2 specimens.
12 (5, 6) *Turritella magnicostata* Conrad. 6 specimens.
13 (17) *Turritella magnicostata?* Conrad (young). 1 specimen.
14 (8, 15) *Cardium biseriatum* Conrad. 7 specimens.
15 (14) *Trigonia syriaca* Conrad. 4 specimens.
16 (25) *Chenopus turriculoides* Conrad. 12 specimens.
17 (36) *Holaster syriacus* Conrad. 2 specimens.
18 *Ammonites syriacus* Conrad. 4 specimens.
19 *Cardium crebriechinatum* Conrad. 1 specimen.
20 *Inoceramus Lynchi* Conrad. 1 specimen.
21 *Isocardia crenulata* Conrad. 1 specimen.
22 *Mactra pervetus* Conrad. 2 specimens.
23 *Natica indurata* Conrad. 1 specimen.
24 *Natica syriaca* Conrad. 1 specimen.
25 *Cidaris spines.* 6 specimens.

Hypotypes.

26 (26) *Ostrea scapha?* Roemer (Conrad). 1 specimen.
27 (29) *Exogyra Boussingaulti* D'Orbigny (Conrad). 8 specimens.
28 *Exogyra Boussingaulti* D'Orbigny (Conrad). 7 specimens.
29 *Ostrea virgata?* Goldfuss (Conrad). Plate 1, figs. 7, 8. 1 specimen.
30 *Ostrea virgata* Goldfuss (Conrad). 3 specimens.
31 *Gryphæa vesicularis?* Lamarck (Conrad). 1 specimen.

Total 22 species.

Species labelled by Conrad but not described.

No.	(Number in parenthesis = original number).	
32	(12) *Cucullæa indurata* Conrad.	2 specimens.
33	*Cucullæa indurata* Conrad.	1 specimen.
34	*Cucullæa syriaca* Conrad.	2 specimens.

The entire report contains figures and descriptions of one hundred species, and the present collection furnishes authentic examples of twenty-two of these, nine of them being represented by figured specimens.

The Syrian collection now in the Yale University Museum came chiefly through American missionaries, and comprises accessions made at various periods during the last seventy-seven years, beginning with 1821 down to 1898. The dates of the various lots, as far as can be determined from the labels and from references to the early volumes of this Journal,* where they are in part described, are as follows:

1821. Specimens sent by Rev. Eli Smith of the Class of 1821, Yale College.
1824 and 1827. Three boxes containing collections made by Rev. I. Bird, Class of 1816.
1840. Specimens from Rev. Hibbert.
——— Specimens from Rev. Dr. A. T. Pratt, Class of 1847.
1857. Collection sent by Rev. H. H. Jessup, Class of 1851.
1861. Specimens from Rev. Dr. Van Dyck.
1898. Specimens in collection of Professor O. C. Marsh.

Since Conrad's report was published in 1852, many of the specimens he described from the Yale Cabinet doubtless belonged to the earliest accessions. Thus, the first considerable description of Syrian fossils is based in part on one of the oldest collections in America and one of the first received from foreign lands.

Yale University Museum,
New Haven, Conn., Feb. 1st, 1900.

* This Journal, I. vol. ix, pp. 337–351. 1825. Description of Minerals from Palestine; by Professor [F.] Hall.

Ibid., vol. x, pp. 21–29. 1825.
Notice of Minerals, etc., from Palestine, Egypt, etc., in a letter from the Rev. Isaac Bird, Missionary, to the editor, dated Beyroot, Palestine, March 15, 1825, with remarks upon the specimens, by the editor. [B. Silliman.]

Ibid., vol. xii, pp. 145–147. 1827.
Notice of various facts relating to Palestine in a letter from the Rev. Isaac Bird to Prof. Hall.

Ibid., vol. xv, pp. 374–378. 1829.
Notices of Palestine, etc., in a letter from the Rev. I. Bird to the editor, dated Lazaretto Rooms, Malta, June 20, 1828, received Oct. 7.

Art. XVII. — *An Electrical Thermostat;* by William Duane and Charles A. Lory.

In some research work that one of us has been carrying on recently, it became necessary to construct an easily adjustable thermostat that would keep the temperature of a bath constant to within $\frac{1}{1000}$th of a degree Centigrade for a considerable length of time. It was thought that this could be accomplished best by means of an electric current, because if the current passed through wires suspended in the bath, or through a conducting bath itself, heat would be supplied throughout the whole bath much more easily and quickly than by other means.

The result of our endeavor to construct such an electrical thermostat has been quite satisfactory. During the trial runs the temperature of the thermostat remained constant to within less than $\frac{1}{2000}$th of a degree Centigrade, although several times the temperature of the surrounding atmosphere varied 12° C. or 15° C. in half an hour.

The general scheme is this. Through a conducting liquid, or through wires immersed in one which is non-conducting, flows an electric current, that is sufficiently large to heat the liquid up to a temperature considerably above the constant temperature required. A system of tubes containing a liquid with a large temperature-coefficient of expansion is placed in the bath. By means of a suitable mechanism the expansion of this liquid interrupts or reduces the strength of the heating current when the required temperature has been reached. The temperature of the bath then begins to fall, whereupon the original current is started again automatically. It might seem at first thought, that, owing to the time required for the heat to penetrate through the walls of the tubes to the expanding liquid within, the making and breaking of the circuit would take place rather slowly, and the temperature of the bath would be oscillatory instead of constant. This is undoubtedly true to a certain extent. Practically, however, with our arrangement of apparatus the variation of temperature is too small to be detected even by a differential thermometer that would indicate a change of temperature of $\frac{1}{2000}$th of a degree Centigrade. Indeed the efficiency of the apparatus is due to the fact that the makes and breaks follow each other so rapidly, that there is not time for the temperature to change perceptibly between them. Often two, three or even more interruptions of the current occur in one second. At first we used an ordinary wash-boiler containing about 150 liters of water as a

bath. The boiler was placed in a large wooden box and packed in around the sides with wool. A light wooden frame immersed in the water served as a rack to hold the wires conveying the current. We encountered considerable difficulty, however, owing to the wires becoming very brittle and breaking after a few days' use. This was the case with wires of copper, iron and German silver. A direct current, too, seemed to produce a much greater effect than an alternating one of the same heating power.

To obviate this difficulty we constructed a wooden trough ($80^{cm} \times 40^{cm} \times 50^{cm}$) and filled it with a weak solution of common salt in water. The two ends of the trough were com-

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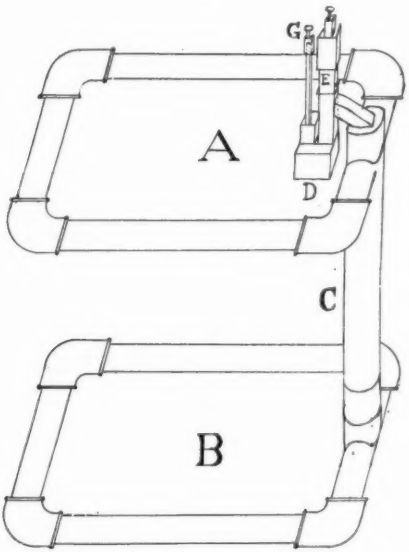
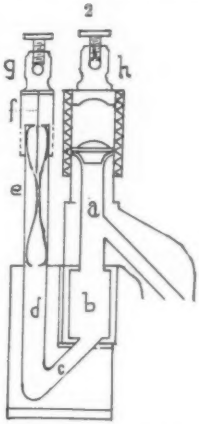


pletely covered inside with sheets of zinc, that served as electrodes by means of which an alternating current from the 110 volt electric light circuit passed through the solution. This method of heating proved very satisfactory.

The liquid in the bath was kept in continual and rapid circulation by means of four stirrers operated by a small water motor.

The tubes containing the expanding liquid were of thin brass about $2{\cdot}5^{cm}$ in diameter. They were fastened together by means of iron joints in the form of two rectangles (A and B, fig. 1). The tube C connected the two rectangles together.

The whole system of tubing was placed in the bath with the planes of the rectangles horizontal and the tube C vertical. The portion G D E is the regulating device. After the tubes had been filled through a small hole in the top of the tube E a brass cap was screwed on the end of E, pressing a small disk of lead tight down over the hole. This formed a perfectly air-tight stopper. The form of the stopper and regulating device finally adopted is shown in fig. 2. The portions of the tube marked *a c* and *d* were of iron; *b* was of brass, and *e* of glass. *a* and the whole system of tubes A, B and C were filled with alcohol, and *b*, *c*, *d* and *e* up to the platinum wire at *f* with pure mercury. The alcohol in the large system of tubes expanding and contracting forced the mercury up and down, making and breaking the contact at *f*. At the joints between *a* and *b*, *b* and *c*, and *d* and *e* were rubber washers; and screw clamps, not shown in the figure, pressed the several parts firmly together.



The reason for inserting the small brass reservoir *b* in the portion of the tube containing the mercury was this. Without it we found that the temperature at which contact was made and broken at *f* kept gradually rising, indicating a small leakage of alcohol. Since the insertion of an easily amalgamated metal in part of the tubing containing the mercury completely corrected this fault, we surmised that the leakage must have taken place along the contact surface between the mercury and the iron tubing. No appearance of alcohol at *f* was noticed, but it could easily have evaporated too rapidly.

The binding posts at *g* and *h* were connected to a circuit containing a dry cell and a relay. The relay opened and closed a second circuit containing an electromagnet, which in turn controlled the main heating circuit.

For temperatures only a few degrees above that of the room the makes and breaks at *f* may open and close the heating circuit completely; but for temperatures 30° or 40° C. above that of the room it is better to arrange the circuits so that the makes and breaks at *f* throw an extra resistance into and out of the main circuit. In this case, of course, the larger of the two main currents must be sufficient to heat the bath up to a higher temperature than the required one, and the smaller insufficient to maintain it at that temperature.

In our apparatus the glass tube *e* was open at the top. A large variation in the atmospheric pressure might produce a change in the temperature at which the makes and breaks take place on account of the slight compressibility of the alcohol. No such effect has been noticed, however. If it occurred the fault could easily be remedied by fastening a tube with a large bulb on its end to the tube *e*. The bulb, of course, would have to be below the surface of the bath, so that the temperature of the air within it would not change.

In practice it is easy to set the regulating device to working at any desired temperature between that of the room and one a few degrees below the boiling point of the liquid in the tubes, as follows. With the cap *h* unscrewed, allow the bath to heat up slowly, and when the desired temperature has nearly been reached, screw the cap down. A little practice will enable one to set the thermometer at a temperature within a small fraction of a degree of the desired one.

The reason that the interruptions of the current follow each other so rapidly is not quite clear to us. It may be due to a slight jarring of the surface of the mercury at *f*. In any case the best results are obtained with pure dry mercury, and when the platinum wire touches the convex surface of the mercury column near its center.

Hale Physical Laboratory, University of Colorado, U. S. A.

ART. XVIII.—*The Toxic Action of a Series of Acids and of their Sodium Salts on Lupinus Albus;* by RODNEY H. TRUE.

IN former papers (1 and 2*) dealing with the toxic action of dissolved salts and their electrolytic dissociation, Dr. Kahlenberg and I presented some evidence bearing on the effect of the ionization of the molecule on the poisonous properties exerted by these substances on the radicles of *Lupinus albus.*

In those papers the belief was expressed that the toxicity of acids was in very large part due to the action of the hydrogen ions formed in the aqueous solution. The question as to the toxicity of the anions and of the residual undissociated molecules, in case ionization was not complete, was raised and postponed for treatment in a further paper. Accordingly, in 1896, Dr. Kahlenberg and I began the study of the toxic action of the sodium salts of a series of acids for comparison with that of the acids themselves. Considerable time has elapsed since then, and now, with the consent of my colleague, I have put together the results of the study. Dr. Kahlenberg is, therefore, responsible for the chemical part of the experimental work; for the botanical part and for the formulation of the results embodied in this paper I, myself, am responsible.

Methods. — Since the method used has been elsewhere described (1) in detail, it will suffice to say here that radicles of *Lupinus albus* were exposed to the action of a series of concentrations of the aqueous solutions of the compounds involved, and the greatest concentration observed, in which the primary roots survived after an exposure of twenty-four hours.

The sodium salts were prepared by adding to solutions of the acids chemically equivalent quantities of sodium hydroxide (NaOH).

Discussion of Principles Involved.—It is a well established fact of chemistry that if, to a solution of an acid, an equivalent amount of a strong base like NaOH be added, a clean-cut reaction will take place, resulting in the substitution of the metal (Na in the compound cited) for the H of the acid, and the formation of water.

Since the physiological activity of $\overset{+}{H}$ has been shown to be very great (2 and 3) and that of $\overset{+}{Na}$ relatively very slight, (1) the effectiveness of the $\overset{+}{H}$ component may be roughly tested by comparing the toxic activity of the acid with that of its sodium salt, differences in the degree of ionization being borne in mind. As is well known, acids dissociate in varying degrees of completeness and the anions or acid radicles may be signifi-

* See Bibliography, p. 192.

cant also, likewise the residue of un-ionized molecules, should dissociation be incomplete. The same general considerations obtain also for the sodium salts. Since in both acid and salt the same anions are found, the difference between the death-limits of acid and salt measures roughly the action of $\overset{+}{H}$ ions, provided that ionization be found in like degree in both. Should it be unlike and incomplete, the toxic action will vary according to the number of molecules ionized (1).

Letting t equal the toxic value of any acid or salt, k the partial-toxicity of the cations, a the partial-toxicity of the anions and m the partial-toxicity of the residual undissociated molecules, then, should ionization be complete, $t=k+a$. Should ionization be incomplete, $t=k+a+m$. In the case of acids, k would represent the partial-toxicity due to $\overset{+}{H}$ ions; in the sodium salts it would represent the partial-toxicity of the $\overset{+}{Na}$ ions.

In hydrochloric acid we have a type of the stronger inorganic acids. It dissociates very freely in relatively strong concentrations and gives a valuable standard of comparison by which to judge the weaker organic acids. It is practically completely ionized at the death-limit characteristic for the white lupine, one molecular-weight in grams dissolved in 6400 liters, hence this case illustrates the simpler instance, $t=k+a$.

The toxic-value of the Na salt, NaCl, is one gram-molecule of the substance dissolved in sixteen liters of water, or briefly, 16. At this relatively great concentration, this salt is not completely dissociated, only about 85 per cent of the molecules being ionized (5). The value 16 represents, therefore, the sum of the partial-toxicities of $\overset{+}{Na}$ ions, $\overset{-}{Cl}$ ions and 15 per cent of undissociated molecules. Here, $t=k+a+m$.

We may obtain an approximate idea of the actual value of $\overset{+}{H}$ ions by a comparison of the toxicity of HCl with that of NaCl. As appears from data just given, it seems to lie near 6400. Strong corroborative evidence may be obtained by a study of sulphuric acid and some of its compounds. This acid is practically entirely ionized (6) at the death-limit for lupines, 12,800, and since it splits off two $\overset{+}{H}$ ions from every molecule, it would have, in chemically equivalent quantities, twice the number of $\overset{+}{H}$ ions found in HCl, and should have its death-limit at one-half the concentration of the mono-basic acid. This has been realized by experiment (1). Should one of the H atoms of H_2SO_4 be replaced by some relatively harmless metal, the death-limit should lie at approximately the same

concentration as that of HCl, provided ionization were complete. These suppositions have been practically realized (1).

We are now able by means of these values to obtain an expression representing approximately the toxic-value of $\overset{+}{H}$ ions. If the molecule splitting off two $\overset{+}{H}$ ions when completely dissociated at the death-limit, gives a value of 12,800, and the same molecule in which one H is replaced by a metal gives one-half that value, plainly all other factors become practically zero in comparison with the H. This ion may, therefore, be given approximately the absolute value of 6400. We see that all other ions concerned are negligible in comparison with $\overset{+}{H}$ ions; hence $\overset{+}{K}$ ions and $\overline{SO_4}$ ions have a relatively insignificant value. If $\overset{+}{H}$ ions have a toxic-value of 6400, plainly in HCl with a toxic-value of 6400, the $\overline{Cl}$ ions are relatively insignificant (1). Results of experiments not yet in print have shown that for the lupines the toxic-values of NaCl and KCl are essentially alike, 16, hence $\overset{+}{Na}$ ions are likewise relatively insignificant.

The question now arises, what is the actual significance of the relatively weak factors, the anions and the undissociated molecules? Since the sum of the toxic-values of $\overset{+}{Na}$ ions, $\overline{Cl}$ ions and 15 per cent undissociated molecules equals 16, plainly no one factor can have a value exceeding 16. Probably any one of them is considerably less. For the present, however, it is sufficient to know that the toxic-value of $\overset{+}{Na}$ ions and the toxic-value of $\overline{Cl}$ ions is each less than 16, or less than $\frac{1}{400}$ that of $\overset{+}{H}$ ions.

In the discussion of the toxic-values of the compounds here concerned, I shall try to fix, as accurately as may be, the partial-toxicity due to each factor.

Discussion of Results.—In order to present in as clear a manner as possible the results of greatest significance in this discussion, I have omitted the details of the individual experiments, only indicating their outcome. In the tables, as well as in the discussion of data, the toxic-values are expressed by the numbers of liters of water in which the molecular-weight in grams, of the substances concerned, must be dissolved, to give the physiological results seen. The same numbers would occur as the denominators of the fractions indicating those parts of a gram-molecule which, dissolved in one liter of water each, would form the strongest concentrations in which the primary radicles of *Lupinus albus* could survive for twenty-four hours.

Since in experiments of this nature the fixing of limits can be only approximate, I do not wish to claim for the numerical results here given a strict mathematical accuracy. These values may be taken as an approach only to the exact relations existing.

In the following table, the data are arranged in six columns. Column 1 gives the names of the compounds discussed. Column 2 gives the death-limit of each substance for the lupines. Column 3 gives the partial-toxicity due to cations. Column 4 gives the partial-toxicity due to anions. Column 5 gives the partial-toxicity due to undissociated molecules *of the acids.* Column 6 gives the degree of ionization found or estimated to exist in the solutions at the concentrations indicated by their death-limits. Since the toxic-value of $\overset{+}{Na}$ ions has been found to lie at less than 16, when dissociation is complete, it is not indicated here in the column giving the toxic value of the cations. It lies always less than 16. The values of the undissociated molecules of the salts are not indicated, since the necessary data for their determination are not at hand. As is shown below, however, these values are usually very small. This may be in part due to their non-toxic nature, and in part to the small proportion of un-ionized molecules left in the solutions at the toxic-limits. It will be seen from the table that these sodium salts ionize very freely.

In ascertaining the data for column 6, I have made use of Ostwald's determinations for the acids. Since Ostwald's investigations (7) extended only to the dilution n-1024, a point lying, in all cases, short of the limits found for the plants, I have resorted to estimates based on the data given.* The degree of ionization of the salts was calculated from Kohlrausch and Holborn's excellent series of tables (4).

* To illustrate the method of calculation used, the following example is given. Ostwald, Zeitschr. f. physik. Chem., iii, p. 174.

Formic acid.

$\mu\infty = 375$

v	—	100^m	Differences.	Ratio of increase.
8	15·22	4·05		
16	21·19	6·63	(2·58)	
32	29·31	7·79	(1·06)	
64	40·50	10·78	(2·99)	(1·33)
128	55·54	14·76	(3·98)	(1·3)
256	75·66	20·12	(5·36)	(1·3)
512	102·10	27·10	(6·98)	(1·3)
1024	104·70	35·80	(8·70)	(1·25)
2048		(46·67)	(10·87)	(1·25)
4096		(60·26)	(13·59)	(1·25)
6144		(68·15)	(8·15)	(1·20)

$K = 0{,}0214$

Interpolated numbers are in parentheses. Last three ratios assumed. Ionization at $v = 6400$ is taken to be roughly 70 per cent.

TABLE OF RESULTS.

Substances.	Death-limit.	Part.-Tox. of cations.	Part.-Tox. of anions.	Part.-Tox. of un-ionized molecules.	Ionization at Death-limit. per cent.
Hydrochloric acid	6400	6400			100
NaCl*	16		16	16	85
Hydrobromic acid	6400				100
NaBr*	16				
Hydriodic acid*	6400				100
NaI*	24				
Nitric acid	6400				
Sulphuric acid	12800	12800			100
$KHSO_4$	6400	6400			100
Fatty series.					
Formic acid	6400	4480	36	1884	70
Na formate	50		36		90
Acetic acid	1600	960	11	629	15
Na acetate	25		11		85
Propionic acid	3200	1088	36	2076	17
Na propionate	50		36		88
Butyric acid	3200	1152	36	2012	18
Na butyrate	50		36		87
Aromatic series.					
Benzoic acid	6400	2432	185	3783	38
Na benzoate	200		185		92
Salicylic acid	6400	6016	85	300	94
Na salicylate	100		85		91
m. oxybenzoic acid	3200	2560	36 ?	600 ?	40
Na. m. oxybenzoate	50		36 ?		
p. oxybenzoic acid	3200	1600	36 ?	1564 ?	25
Na p. oxybenzoate	50		36 ?		
b. nitrobenzoic acid	6400	6400	9–36	00	100
Na o. nitrobenzoate	25–50		9–36		85
m. nitrobenzoic acid	12800	6400	6400	00	100
Na m. nitrobenzoate	400		385 ?		
p. nitrobenzoic acid	12800	6400	6400	00	100
Na p. nitrobenzoate	400		385 ?		
Protocatechuic acid	3200	1792	35 ?	1423 ?	28
Na protocatechuate	50		35 ?		
Gallic acid	6400	2240	85 ?	4075 ?	35
Na gallate	100		85 ?		
Cinnamic acid	12800	2880	785	9135	45
Na cinnamate	800		785		96
Hippuric acid	6400	1920	10 ?	4470 ?	30
Na hippurate	25		10 ?		
Carbolic acid	400	00	00	400	00
Na carbolate	400				

* Results worked out by Miss May Randall, 1899.

Inorganic Compounds.—In the inorganic acids one finds very free ionization, as a rule, so free that in HCl and other halogen acids, nitric acid and sulphuric acid, practically complete dissociation exists at their death-limits for lupines. Since the toxic-values of these acids are essentially alike, 6400 for each H atom of the molecule (1), it is clear that they possess in common a component of great intensity of action, so great as to render other factors negligible in comparison. This common constituent is the equivalent quantity of $\overset{+}{H}$ ions present. In view of this coincidence, one is safe in inferring that the death-limit for $\overset{+}{H}$ ions lies at about 6400 for the lupine.

The sodium salts of these acids, as far as tested, agree in having a low toxic-value; indeed, NaCl is as nearly harmless to lupines as any salt yet tested, having its death-limit at 16. Since at this concentration about 85 per cent of the molecules are ionized, 16 represents the sum of the toxic activities of $\overset{+}{Na}$ ions and $\overline{Cl}$ ions from 85 per cent of the molecules and 15 per cent of residual molecules. If separated into their respective partial-toxicities, one would expect comparatively slight values for each component.

Organic Compounds.—As a rule the organic compounds offer somewhat greater difficulties than the inorganic substances. In general, ionization of the molecule is seldom complete at the death-limit, the sodium salts usually ionizing more freely than the corresponding acids. Consequently it is rare that the effect due to $\overset{+}{H}$ ions is relatively as great as in HCl, and the partial-toxicity due to the anions and undissociated molecules becomes much more important. In some cases it may even exceed that of the $\overset{+}{H}$ ions.

Fatty Series.—In the examples from the fatty series examined, one finds considerable diversity in the results obtained. Formic acid is distinctly the most toxic member of the group and undergoes likewise a distinctly greater degree of ionization,—70 per cent as against from 15 per cent to 18 per cent in the other acids. The result is a distinct prominence relatively and absolutely of the $\overset{+}{H}$ component and a correspondingly reduced effect due to anions and undissociated molecules.

The sodium salts show no similar differences in their action, the formate, propionate and butyrate giving identical death-limits. The acetate is as weak in its poisonous action as any organic Na salt examined. These salts all undergo roughly the same degree of ionization, but from 10 per cent to 15 per cent of residual molecules existing in the solutions at the death-

limits. This fact, while not giving a numerically accurate ground for argument, permits us, nevertheless, to arrive at a rough idea of the relative effectiveness of ions and undissociated molecules. To illustrate, formic acid owes to the action of the anions of 70 per cent of its molecules plus 30 per cent of un-ionized molecules remaining, 30 per cent of its toxic-value, 1920 units. Sodium formate has a toxic-value of about 50. It has been shown above that the partial-toxicity characteristic for 100 per cent of $\overset{+}{N}a$ ions is less than 16; here, therefore, the partial-toxicity due to $\overset{+}{N}a$ ions cannot be more than 14 and is doubtless less. This leaves about 36 units due to anions derived from the ionization of 90 per cent of the molecules plus that due to the residual 10 per cent of molecules not thus ionized. Plainly the toxic-value of either of these factors cannot exceed the sum 36. One may roughly say that the toxic-value of these anions derived from 90 per cent of the molecules is less than 36. Since in the acid 70 per cent of the same anions are formed, in a more dilute solution the action of the anions must be still less. One may, however, safely express it still as less than 36. Comparing this value with the sum of the values of anions plus undissociated molecules, the action of the anions is seen to sink into insignificance, and the toxic-value due to the sum is practically due to 30 per cent of undissociated molecules.

In acetic acid, but 15 per cent of the molecules are ionized at a concentration of one gram-molecule in 1600 liters; nevertheless, 60 per cent of the toxicity of the acid is due to $\overset{+}{H}$ ions derived from this proportion of molecules; 85 per cent of undissociated molecules plus 15 per cent of anions are responsible for 640 units or 40 per cent of the toxicity of the acid. A calculation similar to the above based on the action of the sodium salt shows that in this acid, again, the anions can play no measurable part, the undissociated molecules, of which 85 per cent are present, being responsible for practically 40 per cent of the toxic action of the acid.

In the remaining members of the fatty series studied, the relative importance of the action of the residual molecules increases; in both propionic and butyric acids the undissociated molecules comprise about 80 per cent of the total number, and exert about 65 per cent of the toxic action of these acids.

Aromatic Series.—The study of the aromatic compounds has been very seriously limited by lack of data from the physico-chemical side. This is especially true of the sodium compounds, a large number of which seem not to have received study along the line of their electrolytic dissociation. In but

few cases, therefore, can the line of argument pursued above receive thoroughly satisfactory application to these acids. The toxic-values of the acids and salts have, however, been tabulated, as well as estimated values for the factors, judged from the physiological evidence.

In general, the acids show a very considerable variation in their toxic-values due to their chemical structure. The boundary-concentrations lie between 3200 and 12,800. Dissociation varies between rather wide limits, from 24 per cent in p. oxybenzoic acid to 100 per cent in o. nitrobenzoic acid. The toxic activity here as in the fatty series is preponderant in the cations when dissociation is far advanced. When this is not the case, the influence of the residual molecules exceeds it more or less decidedly. In hippuric, salicylic and o. nitrobenzoic acids, the $\overset{+}{H}$ ions are especially influential. In benzoic and cinnamic acids, the action of the residual molecules is distinctly predominant. In general, the sodium salts show here a very much weaker toxicity than the acids, the death-limit varying between 25 and 100. In Na cinnamate the limit lies at 800 and gives the most vicious sodium salt in the entire list. As far as the available data go, the salts of these acids dissociate freely, from 85 per cent to 96 per cent at the death-limit.

In the case of acids, the dissociation of whose sodium salts has been determined, relations not unlike those obtaining in the fatty series, already discussed, are found to exist.

In the case of benzoic acid, dissociating about 38 per cent at the death-limit, 38 per cent of the toxic effect may be regarded as due to $\overset{+}{H}$ ions, 62 per cent to residual molecules and to anions. The toxic-value of the sodium salt is 200; less than 15 units can be referred to $\overset{+}{Na}$ ions, 185 units are chargeable to 92 per cent of anions and 8 per cent of residual molecules. Since we may safely place the toxic-value of this number of anions at less than 185 units, the toxic-value of 72 per cent of undissociated molecules is more than 3783.

In the m. and p. nitrobenzoic acids it becomes difficult to apply the line of reasoning thus far used to the explanation of the results. The possibility exists, of course, that the death-limits are not correctly located. The thought also suggests itself that at this great dilution hydrolytic changes may take place affecting the essential structure and physiological properties of the molecule. Owing to this anomalous behavior, a further study of these isomers seems especially advisable.

Cinnamic acid deserves a passing comment. Although a mono-basic acid, it has an extremely toxic effect, equalling that of H_2SO_4, which cuts off two H ions per molecule at the death-

limit. This unusual viciousness is plainly to be charged in large part to the undissociated molecules, but the anions here seem to be much more significant than in any acid before mentioned. Probably about 785 units are chargeable to the anions, about 15 units to $\overset{+}{Na}$ ions, about 2880 units to $\overset{+}{H}$ ions and about 9135 units to the residual molecules.

For comparison with the above organic acids, in which the acid H is in the carboxyl form (COOH), carbolic acid and its Na compound have been added. Here the H is in the hydroxyl form (OH). The toxic-value of carbolic acid is 400 (8), about $\frac{1}{16}$th that of the completely ionized mono-basic acid. A study of the electrical conductivity has shown (9) that ionization is practically absent here, and the undissociated molecules form, of course, the only factor. No diminution of the toxic-value would be expected, therefore, in the Na compound. As a matter of fact (8), the toxic limit of the Na compound is likewise 400. This is a situation fairly typical for the phenols.

Summary.—In closing, the main points brought out in the course of the above discussion may be summarized as follows:

Given the degree of ionization of the molecules of an acid and of its Na salt at the limit-concentrations, it is possible approximately to analyze the resultant toxic effect into those component parts which are due (1) to the $\overset{+}{H}$ ions, (2) to the anions and, in case ionization is incomplete, (3) to the residual undissociated molecules.

In the inorganic acids cited, complete ionization exists at the limit-concentration, e. g., in HCl, HBr, HNO_3 and others. The anions are probably toxic, but in a very slight degree when compared with $\overset{+}{H}$. Consequently, in these acids the purest $\overset{+}{H}$ effect is seen and the minimum effect from other constituents. $\overset{+}{Na}$ ions are but slightly toxic.

In both the fatty and the aromatic series of organic acids, the acids dissociate much less freely as a rule and exert their toxic action usually through three factors: $\overset{+}{H}$ ions, anions and residual undissociated molecules. In case dissociation is well nigh complete, the partial-toxicity of $\overset{+}{H}$ ions usually exceeds that of other factors. In case ionization takes place less freely, the undissociated molecule plays an important part, often exceeding that played by $\overset{+}{H}$ ions. In general, such residual molecules possess a great degree of toxicity. In cinnamic acid over 77 per cent of the total toxic action is due to undissociated molecules.

In general, the anions of organic acids possess relatively slight toxic properties, oftentimes well nigh so slight as to be neglected, as in acetic and hippuric acids. In benzoic acid, and especially in cinnamic acid, the anions are distinctly toxic but to a degree relatively slight when compared with the action of $\overset{+}{H}$ ions or of the undissociated molecules.

Since $\overset{+}{Na}$ ions are but weakly toxic and the anions are oftentimes relatively ineffective, it follows as a rule that $\overset{+}{Na}$ salts have in general from but $\frac{1}{2}$ per cent to 3 per cent of the toxic-value of the corresponding acids.

Carboxyl hydrogen, as seen in the above organic acids, is many times more toxic than hydroxyl hydrogen, as seen in carbolic acid. Since practically no $\overset{+}{H}$ ions are formed in the phenol, the Na compound gives no marked change of the toxic-limit.

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ART. XIX.—*Explorations of the "Albatross" in the Pacific;* by ALEXANDER AGASSIZ.

III.

[*Letter No. 3*, dated Suva Harbor, Fiji Islands, December 11th, 1899, to Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries, Washington, D. C., by Alexander Agassiz.]

WE left Papeete, November 15th, after coaling and refitting on our return from the Paumotus. During our trip to Suva we made a few soundings from Tahiti to Tonga, striking the northern extension of the deep basin lying to the eastward of Niue; the depths ranged from 2472 to 2882, the bottom being red clay. This would indicate a greater extension westward of the zone over which the manganese-nodule bottom is known to extend.

After leaving Niue we steamed for the deep hole of the Tonga-Kermadec Deep, about 75 miles to the eastward of Tonga-Tabu, and in 4173 fathoms made a haul with the Blake beam-trawl, by far the deepest trawl haul yet made. The gear was carefully inspected, and strengthened as far as practicable by Captain Moser, and it was with considerable anxiety that we laid out 5000 fathoms of wire rope for our haul. Fortunately, everything went off successfully, and we landed the trawl safely back on deck. To my great surprise we found in the bag a number of large fragments of a silicious sponge belonging probably to the genus Crateromorpha, which had been obtained by the Challenger in the Western Pacific, but in depths less than 500 fathoms. We also brought up quite a large sample of the bottom; it consisted of light brown volcanic mud mixed with radiolarians.

We decided to trawl at 4173 fathoms rather than wait for a possibly deeper sounding, as the conditions for work were admirable and we did not care to run any risk from a change of weather. After our haul we made a still deeper sounding in the proximity of the 4762-fathom sounding marked on the chart, and found 4540 fathoms, with the bottom of the same character as at the place where we trawled. We also took a couple of soundings in the line from Vavau to the southern extremity of the Lau Group in Fiji, but found, as we expected from the soundings given farther south, comparatively shoal water, viz: 1381 fathoms. In the channel north of Yangasá, where we cross the Lau Plateau, between Yangasá and Mothe, we found 453 fathoms, with bottom composed of coral sand, pteropod ooze, and a few globigerinæ. Between Namuka and Yangasá we obtained 324 fathoms; between Namuka and

Marambo, 600 fathoms; between it and Kambara, 450 fathoms; and finally, about 15 miles west of Kambara, we sounded in 990 fathoms. These soundings would indicate a continuous plateau of moderate depths from Wailangolala south upon which the islands of the Lau Group rise.

On our way back to Papeete from the Paumotus we examined the eastern coast of Tahiti, and from Papeete examined the western coast as far as Port Phaeton, at Tararoa Isthmus. We examined, in a general way, the Leeward Society Islands: Murea, Huaheine, Raiatea, Tahaa, Bora-Bora, Motu Iti, and Maupiti. There are excellent charts of the Society Islands, so that it was comparatively simple to examine the typical points of the group and to gain an idea of their structure as far as it relates to coral reefs. The Society Islands are all volcanic islands edged with shore platforms, some of great width, upon which the barrier or the fringing reefs of the islands have grown. The structure of the reefs of the Society Islands is very similar to that of the Fiji reefs round volcanic islands. A comparison, for instance, of the charts of Kandavu, Viti Levu, Mbengha, Nairai, and of other volcanic islands in the Fijis, with those of the Society Group, will at once show their identity. Huge platforms of submarine denudation and erosion characterize both, with fringing and barrier reefs determined by local conditions. Perhaps it is easier to follow the changes which have taken place in the Society Islands; and such islands as Tahaa and Bora-Bora, where we anchored, as well as Maupiti, are admirable examples and epitomes of the structure and mode of formation of the coral reefs of that group.

In Motu Iti and Tetuora the volcanic peaks have disappeared leaving nothing but a shallow platform, upon the outer edges of which sandy coral islets have been thrown up. There is, however, one point in which the barrier reefs of the Society Islands differ from those of Fiji. The barrier reefs in Fiji are generally indicated merely by reef flats, upon which the sea breaks, and an occasional rocky islet or negro-head; only rarely do we find sand keys upon the fringing reefs of the islands of Fiji. In the Society Islands, on the contrary, we find the line of the barrier reef usually well indicated by long lines of narrow islets thrown upon the reef platforms, exactly as they are in the Paumotus. These islands and islets are usually well wooded, and thus give a very peculiar aspect to the barrier reef. In the case of Bora-Bora, Maupiti, and Aitutaki, for instance, we have a central volcanic peak of considerable height surrounded by a wide lagoon, the sea edge of which is formed by a fringe of wooded islets and islands forming a more than half-closed ring around the central island, which, in

Bora-Bora and Maupiti, rise in slopes and nearly vertical walls, the former to a height of nearly 2400 feet, the other to about 1100 feet.

The only island of the Cook Group which we examined was Aitutaki, as Atiu is composed of elevated limestone, and Rarotonga is volcanic; I hoped we might find that atoll to be in part volcanic and in part composed of elevated coralliferous limestone; we found it to be volcanic, an island with the structure of Bora-Bora on a smaller scale.

We anchored at Niue, an island composed of elevated coralliferous limestone showing three well-marked terraces, the lowest of not more than 5 to 10 feet and in many places disappearing completely, the limestone cliffs rising vertically from the sea well into the second or even the third terraces. The vertical faces of the cliffs are dotted with caverns and deeply indented by small cañons extending at right angles to the face of the shore or forming blunt headlands separating short reaches of coral sand beaches.

The second terrace varies in height from 50 to 60 feet, the third from 90 to 100 feet. The second terrace is deeply undercut; and in the higher vertical cliffs extending into the third terrace from the sea, the former positions of the terraces are usually indicated by lines of caverns. There are corals on the sea slopes of the first terrace, extending to 10 or 12 fathoms, growing much as they are found at Makatea.

From Niue we went to the Tongas, which we found a most interesting group. The elevated Tertiary coralliferous limestones take here their greatest development, and are on a scale far beyond that of their development in the Lau Group of the Fijis, or the Paumotus. The first island of the Tongas we visited, Eua, is perhaps the most interesting of the islands, composed of Tertiary elevated coralliferous limestone I have visited. From Dana's account of it, evidently given at second hand, I expected to find an island somewhat like Viti Levu on a very much smaller scale. But as we steamed up to it from the east there could be no mistaking the magnificent face of nearly vertical limestone cliffs forming the whole eastern face of the island, and at points rising to over a thousand feet in height. At all projecting points lines of terraces were plainly marked: at the northern point three could be followed, and at the southern extremity five, with traces of a sixth perhaps.

Upon rounding the southern extremity of the island we could see that the island was composed of two ridges, running north, separated by a deep valley, the western ridge being much lower than the eastern, not rising to a greater height than a little over 500 feet. The western ridge is also composed of limestone, and at the headlands we could trace three ter-

races. There is a narrow shore platform along the western face, at many points of which there are blow-holes where the sea throws up spray to a considerable height, but these blow-holes are best seen off Cook Point, the southern extremity of Tonga-Tabu.

As we steamed along the western face of Eua Island we could see the ridges of the eastern side rising above the crest of the lower ridge, its slopes indicating a valley of considerable size. We anchored at English Roads, opposite the outlet of the drainage of the interior basin, where a small river has cut its way through a depression in the shore terrace. On landing we followed the crest of the western ridge for a few miles and could see the whole valley forming the basin of the island lying between the two ridges, at our feet; the slopes leading to the bottom are quite gentle, and the valley dips very gradually northward back of the outlet on the western shore. Nothing could show more clearly that such an island was not an elevated atoll, but a plateau which has been eroded and denuded for a long period of time by atmospheric and other agencies, and in which a deep basin-shaped valley with gentle slopes has been gouged out—a plateau similar to that of Tonga-Tabu Island and of Vavau, but of greater height and less extent.

To the westward of the Tonga Islands is a line of volcanic islands extending nearly 200 miles, from Honga Hapai to Fanualai, some of which have been active very recently. Falcon Island disappeared in 1898, and Lette is still active. This line of volcanoes runs at a distance of from 15 to 20 miles parallel with the trend of the four irregularly-shaped plateaux upon which rise the Tonga Islands. They are the summits of a great ridge, over 200 miles in length, sloping very gradually to the westward and being somewhat more steep to the eastward, into deep water, towards the smaller platforms from which rise the volcanic peaks of the group. The plateaux of Tonga-Tabu, N muka, Haapai, and Vavau, are separated by deep valleys connecting the eastern and western flanks of the ridge. These four plateaux rise abruptly from the 100-fathom line. The extremity of the southern one is occupied by Tonga-Tabu Island. The land behind the cliffs of its southern coast rises to a height of over 250 feet, and slopes northward very gradually to form the low land which occupies the northern coast of the island, and is, except at Mount Zion and Cook Hill, not more than from 10 to 20 feet above the level of the sea. At Cook Point and along the southern coast three terraces are indicated. The northern coast is deeply indented by shallow bays, full of islands, reef flats, and reef patches, on which corals grow in great profusion.

In a distance of nearly 10 miles northward of Nuku-Alofa the plateau is nowhere more than 15 fathoms deep; and a long tongue runs northward, gradually deepening into 20 to 50 fathoms to the 100 fathom line.

The Tonga-Tabu plateau is separated from the Namuka Group plateau by a funnel-shaped channel with a depth passing rapidly into 300 fathoms from the 100-fathom line. The Namuka plateau is rectangular. The principal island is Namuka, where we anchored. We found the island to be composed of Tertiary elevated coralliferous limestone, with a shallow sink, filled with brackish water, occupying the southeastern part of the island. The sink is separated by a high sand beach, about 200 yards wide, from the sea.

Namuka Iki, the island next to Namuka, we found to consist, at its southern extremity, of stratified volcanic material, resembling somewhat the so-called soapstone of Fiji. I was told that other islands in this group, near Tonumeia, in the center of the Namuka plateau, were volcanic. Mango, as we could see it from our anchorage, appeared to be volcanic. So that this part of the Tongas is, like the Lau Group in Fiji, made up of islands in part volcanic and in part composed of elevated coralliferous limestone. The eastern edge of the Namuka plateau (which we did not visit) is edged with small low islands. We merely steamed by the western islands of the Haapai Group, but close enough to see that Tongua, Kotu, and Fotuhaa, which are respectively 120, 120, and 200 feet high, are composed of elevated limestone. The eastern flank of the Haapai plateau is edged with long, low islands, with extensive coral reefs along the reef flats of these islands.

The Haapai plateau is triangular, with isolated islands rising on the northwestern side from the deep water separating it from the Vavau plateau. It is separated from the Namuka plateau by a narrow channel with over 300 fathoms of water.

The northernmost plateau of the broad ridge of the Tonga Islands is the Vavau plateau. This is elliptical, with a long tongue extending on the eastern face of the ridge toward the northern point of the Haapai plateau, ending in isolated banks (the Disney and Falcon banks), lying to the northward of the broad channel, with over 400 fathoms separating it from the Haapai Group. The Vavau Group is by far the most picturesque of the Tonga Islands. It consists of the principal island of Vavau, extending across the northern part of the Vavau plateau. Several parts of the island of Vavau, as at the entrance to the harbor of Neiafu, and at Neiafu, are finely terraced; four terraces are indicated there, and other flat-topped smaller islands show traces of two or three terraces. The northern edge of Vavau Island rises to a height of more than

500 feet, and slopes in a general way southward and inland. The southern shore is deeply indented by bays and sounds, and flanked by innumerable islands and islets, some of considerable height (150 to 250 feet) which gradually become smaller and smaller as they rise toward the southward and eastward, these islands having been formed from the denudation and erosion of the greater Vavau. They form tongues of land and sea and sounds of all shapes and sizes, showing the traces of the former land connections of the islands and islets, and their disintegration on the eastward and southward by the action of the sea. The islands and islets to the southward of the main island rise from more or less extensive reef flats which stud the whole plateau, and on which corals grow in great profusion (mainly Millepora, Porites, Pavonia, Pocillopora, Fungia, and Astrea), to a depth of 5 to 6 fathoms in the sounds. In the Namuka Group they extended in the more open waters to 14 and 16 fathoms.

It is evident that in the Tonga Group, which is a very extensive area of elevation, the recent corals have played no part in the formation of the masses of land and of the plateau of the Tonga Ridge, and that here again, as in the Society Islands and the Cook Islands, both also in areas of elevation, they are a mere thin living shell or crust growing at their characteristic depths upon platforms which in the one case are volcanic, in the other calcareous, the formation of which has been independent of their growth.

We expect to leave for the Ellice, Gilbert, and Marshall Islands as soon as we can coal and refit.

Art. XX.—*On Ægirite Granite from Miask, Ural Mts.*; by L. V. Pirsson.

Some little time since, there was received in this laboratory a small suite of rock specimens from Krantz in Bonn representing the mica-nephelite syenite from Miask in the Urals, long known as "miascite" from the locality. On account of a pressure of work in other directions, the sections from these rocks have been only recently examined for classification and arrangement. It was at once seen that one of them is an ægirite alkali granite, a rare and interesting type of rock.

Most of the specimens agree well with the descriptions of the common types of this locality given by several authorities.* They are light gray to white rocks spotted with glittering black plates of biotite often collected in stringy layers so that the rock has a pronounced gneissoid character. Under the microscope the sections show a dark mica, probably biotite, alkali feldspars of various kinds, albite, microcline, microperthite, cryptoperthite, etc., with nephelite, sodalite and cancrinite. They frequently indicate that the gneissoid structure is secondarily induced by dynamic pressures from the undulatory extinctions and broken character of the minerals.

The specimen which is the occasion of this note is a light colored rock of much the texture and feeling of a rather firm sandstone of medium grain; it has a distinctly saccharoidal character. It does not possess the glittering black mica of the other types but is spotted with small grains of a dull black ferro-magnesian mineral; these, a millimeter or less in diameter, are not regularly sprinkled through the rock, but are gathered in clusters or small areas, where they are closely crowded, while the intervening spaces are quite devoid of them and show only the light feldspathic grains. The actual amount of this, the only dark component, is small compared with the quartz and feldspar, and the rock is therefore distinctly leucocratic in character.

In thin section the minerals observed are apatite, zircon, ægirite, albite, microcline, orthoclase and quartz. The apatite is comparatively rare in small stout prisms; the zircon is in minute well crystallized prisms and larger anhedra; it is more abundant than apatite.

Albite is rather abundant and well twinned according to the albite law, not according to the carlsbad. It is recognized by its optical relations and measurements and by Becke's method on contacts with quartz.

Microcline is seen in small fragments and in places the unstriated alkali feldspar has transitions through areas of undu-

* Rose, Reise nach dem Ural, vol. ii. p. 42, 1842; Mouchketov; Rosenbusch, Mass. Gest. 3d Aufl. p. 178, 1896; Zirkel, Lehrb. d. Petr., 1894, p. 415; Karpinsky, Guide VII Intern. Cong., No. V (Versant orientale de l'Oural, 1897, p. 21).

latory or rolling extinction into those of undoubted microcline twinning. The inference is not far that this twinning has been produced by pressure, and the microcline is therefore not an original constituent but a paramorphic one.

The ægirite has the usual properties of this mineral and is present in distinct but not well crystallized grains.

The quartz is recognized by its being a mineral of low refraction and birefringence, colorless, without cleavage and of positive uniaxial character. It occurs in two ways, in the formless irregular areas between other more automorphic constituents common to granitic rocks, and in clear round grains embedded in the feldspars and appearing like the corrosion quartz of the French petrographers. Everywhere the quartz shows optical strains and broken undulatory extinctions, indicative of its having been subjected to severe pressure; its total amount in the rock is considerable.

The structure indicates also that the rock has been under dynamic pressure in that the constituents appear broken, angular and with at times a distinct approach to the "mortar" structure. Aside from this the structure is nearest that of an aplitic granite.

Classification.—From what has been said it is clear that the rock is an ægirite granite or taking into account its sugar granular structure and relative paucity of dark minerals, perhaps better an ægirite aplite. Its alkaline character points clearly to its being a differentiation product of acid oxyphyric, leucocratic character of the alkaline magmas at Miask, and it would seem probable that it is from a dike possibly of some size which has suffered from orogenetic movements.

In the literature of the Miask area accessible* to the writer there is no mention of this type, and as it is a very interesting and important one in several ways, the author has thought well to call attention to it, and also with the hope that more may be learned of its geologic and genetic relations.

Quartzose igneous rocks containing ægirite are known but are still rare. They are known chiefly in the finer-grained and porphyritic textures such as the grorudites of the Christiania region, the Bearpaw Mts., Montana and in the rockallite of Rockall Island, and the granite porphyry of the Judith Mts. In alkaline granites the iron-bearing component is usually a hornblende, such as riebeckite and ægirite I have been able to find mentioned but once in the literature by Brögger† in a granite near Drammen in South Norway.

* Rose, Reise nach dem Ural. 1842, vol. ii; Guide des Excur., VII, Cong. Geol. Inter., No. V, Karpinsky. Karpinsky mentions two or three others in Russian journals.

† Spaltenverwerfungen Langesund-Skien, Nyt. Mag. for Naturvid, vol. xxviii, p. 40.

Sheffield Laboratory of Mineralogy and Petrography.
Yale University, New Haven, January, 1900.

Art. XXI.—*Illinois Gulch Meteorite;* by H. L. Preston.

[Read before the Rochester Academy of Science, Jan. 23d.]

The Illinois Gulch siderite was found in Illinois Gulch, Deer Lodge County, Montana, in 1899, on the bed rock about four feet below the surface, by J. Parle while placer mining.

The mass was somewhat ham-shaped, as will be seen by the following cut.

Illinois Gulch Meteorite.*

Its dimensions are $63 \times 104 \times 105^{mm}$ in its greatest diameters. There are two rather large typical pittings, one on either side, with numerous quite small ones and three sharp angular ridges on the upper or necked surface. But little genuine crust is left, the bright silvery metallic iron being visible in small patches through the oxidized surface, over a portion of the mass.

On certain portions of the mass, particularly in the deeper pittings, there is quite a thick deposit of carbonate of lime, showing that it had lain for a long time in the position where found.

In slicing the mass into five sections, the protosulphide of iron, troilite, was found only on one section, and on this in very small quantities; the largest nodule being only 6^{mm} in diameter, with numerous small fissures, from 1 to 5^{mm} in length, extending in various directions from it, that are filled with the same material.

This nodule occurred in the lower center of the section. At the extreme right, within 5^{mm} of the edge of the section, occurred another patch of small fissures, covering an area of about 8^{mm} in diameter, filled with troilite.

* The horizontal lines on cut are due to the fact that the photograph was taken after the mass had been cut.

On etching the iron, no distinct figures of any character were brought out, but a surface of a dark gray groundmass was left filled with bright silvery-white flakes, without any definite form, or sharp line of contact, between them and the dark grey groundmass.

Over the surface are scattered in single crystals, occasionally in groups, a very dark steel gray crystallization, from $\frac{1}{2}$ to 1^{mm} in length and $\frac{1}{2}^{mm}$ or less in width, that are probably the phosphide of iron and nickel, rhabdite.

The character of the etched surface of this iron is more nearly, lacking the supposed rhabdite crystals, like the Morrodal Norway siderite, than any other with which I am acquainted.

This mass is in the possession of Ward's Natural Science Establishment, and when received by them weighed 2,435 grams, but at that time a fragment weighing possibly fifteen grams had been chiseled off the end of the narrow neck.

An analysis of this siderite by Mariner and Hoskins, of Chicago, gave

Fe	92·51
Ni	6·70
Co	·16
Si	trace
P	·62
C	·01
	100·00

Specific gravity 7·7.

This meteorite will be designated the "Illinois Gulch" meteorite, Deer Lodge County, Montana.

ART. XXII.—*The Silurian-Devonian boundary in North America. I. The Chapman Sandstone fauna;* by HENRY S. WILLIAMS.

THE identification of the Chapman sandstone fauna of Aroostook County, Maine, with the typical Ludlow "Tilestone" fauna of Murchison, furnishes important new evidence bearing upon the question of the exact boundary between the Silurian and Devonian systems in North America. Before the identity was recognized by the author, the general position of the fauna, in relation to the change in sedimentation from limestone to the sandstones of the Gaspé peninsula, was seen to give probability of the presence of an uppermost Silurian fauna in this part of the continent. A discussion of this subject was arranged to take place at the summer meeting of the Geological Society in 1899, when Mr. Schuchert proposed to present arguments for inclusion of Lower Helderberg faunas in the Devonian. The absence of Mr. Schuchert led to the postponement of the discussion to the winter meeting in December, 1899. At that meeting, I briefly referred to the facts here given, but did not discuss the paleontological evidence upon which the identification was based. In the present article it is proposed to state briefly the paleontological reasons for believing the Chapman sandstone fauna to be the American equivalent of the "Tilestone" fauna of Wales, leaving the full description and illustration of the fauna for a future work.

The accurate determination of boundary planes between geological systems on different continents is of greater importance than local geologists are wont to appreciate. As in the case of current money, the crucial test of a geological classification is most deeply felt when attempt is made to pass it in a foreign country. All the geological system boundary-planes were first determined outside America; and, following the rule of historical precedent, such standard planes must form the basis of comparison for all local standards set up in America. For our own uses alone it is not important that our systems should accurately correspond at their limits with the same systems of Britain and Europe. They differ more or less in their fossil contents; and a general agreement in boundaries, adjusting them to the peculiarities of our formations, is sufficient for the mapping and discussion of our local geological problems.

When, however, the history of organisms is under discussion, it becomes essential to correlate with accuracy the chief time boundaries for all continents; and for this purpose a few

datum planes must be established, whose exact correlation, with the standard section in the country where the time boundary in each case was first defined, is known with precision. Such boundaries, it is granted, were purely arbitrary in the first place; but once established they become, like Greenwich or the Christian era, standards for all future scientific uses.

The fact is well known to paleontologists that the faunas of formations of the same geological age often differ widely in their species in separate regions of the same continent. And the faunas now living on the west and east coasts of America, under like conditions of temperature and environmental conditions, contain very few identical species. Even in the same sea (as the fauna off Florida and that off New England), modern faunas differ as greatly as two contiguous faunas of the geological column. These facts make it essential for the student of evolution to distinguish between modifications of a fauna which are (*a*) coördinate with the change of place (geographical distribution), and those (*b*) coördinate with passage of time (geological range). It is for such reasons that I have been led to consider the determination of geological boundaries as worthy of exhaustive and painstaking investigation.

Such methods of precision were applied in the determination of the American equivalent of the Cuboides zone.* And, as a secondary result of that study the origin of the Neodevonian faunas of New York State was traced to a northwestern source, while the Mesodevonian faunas were found to be more closely related to southern faunas (recognized in Brazil, South America) and not identical with the common Mesodevonian fauna of Europe.

Although a well-marked biological boundary between the Devonian and Carboniferous of North America is found, where *Spirifer disjunctus* is replaced by *Spirifer marionensis*, and *Syringothyris* first appears, the corresponding boundary in standard European sections is so indistinct that I do not have confidence that this boundary as drawn in America will agree precisely with the European standard.

The discussion of the Hercynian problem has resulted in the placing, by several of the best continental European paleontologists, of the Silurian-Devonian boundary below the Hercynian fauna. Kayser,† followed by others, has adopted the opinion that the American equivalent of the Hercynian fauna is to be found in the Lower Helderberg.

* The Cuboides Zone and its Fauna: a discussion of Methods of Correlation. Bull. Geol. Soc. Amer., vol. x, pp. 481–501, pl. xi–xiii, 1890.

† Die Fauna der ältesten Devon-Ablagerungen der Harzes. Abhand. geol. special Karte, Preussen, etc. Band ii, heft 4, pp. 284–285, 1878.

Dr. J. B. Clark and Mr. Schuchert* have attempted to prove, on paleontological grounds, that the Lower Helderberg fauna has a Devonian "aspect," and, trusting to their theories, have proposed to classify the formations containing the typical Lower Helderberg faunas in the Devonian system.†

When Professor Kayser's paper first appeared I was struck with the force of his paleontological argument for classifying the Lower Helderberg and Hercynian faunas together; but I was not then satisfied with the proof of the Devonian age of all the faunas so classified. When Dr. Barrois' paper, on the Erbray faunas appeared,‡ it was gratifying to find confirmation of this opinion.

Dr. Freck's papers§ were also emphatic in claiming a Devonian age for the Hercynian, and the combined evidence of these gentlemen (and others taking part in the discussion), pointed very strongly to the conclusion that we must drop our Silurian-Devonian boundary below the main part of the Lower Helderberg, if we would adopt European (continental) usage.

The similarity of the Gaspé section to the typical Welsh sections of the Silurian system, running up to the base of the Old Red sandstone, gave me hopes that a study of the sections in northern Maine might reveal some faunas representing the upper part of the Silurian more closely than do the faunas of New York. As the fossils of Maine were studied, a transition fauna was found which throws considerable light upon the exact position of the boundary plane between the two systems, Silurian and Devonian, in our North American rocks.

The fauna referred to was first discovered by Olof O. Nylander, in the town of Chapman, Aroostook County, Maine, in a sandstone, called Chapman sandstone, in a report on the geology of Maine recently made to the U. S. Geological Survey [which will appear as Bulletin No. 165]. The fauna is being described and figured, but a preliminary examination of it has revealed its close correlation with the Ludlow Tilestone fauna of Murchison, and still more closely with the Upper Arisaig fauna, D of Honeyman's section, which was "unhesitatingly referred to the Ludlow Tilestone" by Salter, in 1862.‖

This Chapman sandstone fauna is the latest marine paleozoic fauna so far recognized in Maine, unless the Moose River fauna with Oriskany species be a little later. It is contained

* The nomenclature of the New York series of Geological formations, Science, N. S, vol. x, pp. 874–878, Dec. 15, 1899.

† See paper read at the Geol. Soc. America, Washington, December, 1899.

‡ Fauna du Calcaire D'Erbray, by Charles Barrois, Mem. de la Soc. géologique du Nord, tome iii, April, 1889.

§ Ueber das rheinische Unterdevon und die Stellung des "Hercyn," by Fritz Freck; Zeitschr. d. Deutsch. geolog. Gesellschaft; Jahrg. 1889, pp. 175–287, etc.

‖ Quart. Jour. Geol. Soc., xx, p. 334, 1864.

in a massive brown sandstone and argillaceous layers stratified therewith. Its comparison with other faunas links it with the so-called Oriskany of the Moose River region further west, and also with the early beds of the Gaspé sandstone further east. For this general region it is a representative of the transition zone from calcareous formations, which are unmistakably Lower Helderberg in age, up to coarse gray and red sandstones containing Devonian plants, reported to be seven thousand feet thick on the Gaspé peninsula and to represent the Old Red sandstone phase of the Devonian system.

The fauna contains some twenty-five or thirty good species, a few of which can be identified with species of the Tilestone and Upper Arisaig faunas already described. A few Gaspé species described by Billings are closely approached; but, as a fauna, the resemblance to the typical Tilestone species of Murchison's Silurian system is most striking and suggestive.

The faunas, as reported in my preliminary list, are as follows, viz:

Fauna of 1099 A, south branch of Presque Isle stream in Chapman township, Aroostook Co., Me.

Rensselæria (Beachia) n. sp., cf. B. suessana.
Holopea cf. Danai.
Loxonema cf. planogyrata.
Pleurodictyum sp.
Spirifer gaspensis.
Orthonota n. sp. (cf. undulata).
Palæoneilo cf. constricta.
P. cf. plana.
P. cf. maxima.
P. 5 or 6 new species.
Sanguinolites n. sp. (cf. clavulus).
Leiopteria, six species.
Pterinea rectangularis (cf. flabellum).
P. (three species).
Cf. Glyptodesma sp.
Cypricardella cf. gregarius.
Nucula (n. sp.).
Beyrichia tuberculata Klöden.
Psilophyton princeps.
Stem large plant.

The second fauna, 1099 C, is from Edmund's Hill, in the northern part of the same township:

Rensselæria (Beachia) n. sp. cf. suessana.
Spirifer arrectus, cf. "cyctopterus" Billings.
S. cf. concinnus.
Homalonotus cf. Vanuxemi.

Chonetes Nova-Scotica Hall (cf. sarcinulatus var. plana Schnur).
Chonetes canadensis Bill (cf. Leptæna lata Sow.).
Bellerophon, two species.
Holopea sp.
Several gastropods.
Avicula cf. textilis.
Lamellibranchs, several genera and species.
Orthoceras, a fragment.
Tentaculites.
Beyrichia tuberculata Klöden.
Plant fragments.

Loose specimens, picked up in various places in the county, have furnished in addition to the above :

Sp. raricostus Bill.
Avicula cf. securiformis.

The significance of the correlation of this Chapman sandstone with the Tilestone of Murchison, is found in the fact that *the Tilestone contains the topmost fauna of the original Silurian system of Murchison.* This fauna was described by Sowerby in the "Silurian System" (1839), and afterwards the Tilestone was placed by Murchison himself in the Silurian ("Siluria," 1854). This change was brought about by the recognition, by Murchison, that paleontological evidence is of greater importance in the determination of the age of rocks than petrographical evidence. By the study of "Silurian System," it is perfectly evident that the Silurian system was intended by Murchison to include all the fossiliferous formations lying below the Old Red sandstone. We find this indicated clearly on pages 3 and 4, and still more clearly expressed on page 7 of the Introduction of "The Silurian System," where are found the following words (referring to the name Silurian): "The term was no sooner proposed than sanctioned by geologists, both at home and abroad, as involving no theory, and as simply expressing the fact, that in the 'Silurian region' *a complete succession of fossiliferous strata is interpolated between the Old Red Sandstone and the oldest slaty rocks.*" We find that the reason for including the Tilestones in the Old Red was the fact that the soil weathered out reddish in the same way as the Old Red sandstone did where it was typically represented. These Tilestones, however, were not always red in themselves; but, on passing below, the typical Upper Ludlow weathered gray. This seems to have been the prime reason in the mind of Murchison for classing the Tilestones with the Old Red. When, however, the first edition of "Siluria" was written, the fact that the species of this fauna

were marine and not freshwater types, and that some of them were identical with species in the formation below (which he called Silurian), led Murchison to call this Tilestone the top member of the Silurian instead of the bottom of the Old Red. In "Siluria" appears a concise description of the transition from the Ludlow rocks into the Old Red sandstone, as seen in Carmarthenshire and Pembrokeshire: "In all these places, strata of dull greenish-gray argillaceous sandstone, minutely micaceous, differing chiefly from the type of the Ludlow of Shropshire in being harder and thicker bedded, and which repose on rocks with Upper Silurian fossils, plunge under red and green strata (the red rab of Pembroke), or bottom beds of the Old Red sandstone" (p. 141).

The typical localities, from which the Tilestone fossils came, are Felindre on the Teme and Horeb Chapel, in the valley of Cwm Dwr, between Trecastle and Llandovery near Cwn Dwr. In the "Silurian System," the passage beds near Felindre are described as "hard, greenish, and reddish, highly micaceous sandstone, which contain the *Leptaena lata* and the *Terebratula nucula* of the Ludlow rock, together with casts of several shells, identical with those found in the tilestones of the Cwm Dwr, Caermarthenshire, and which have never been found in the Silurian System below its junction with the Old Red Sandstone" (p. 191).

The reason for placing the base of the Old Red sandstone above these tilestones is stated in the following passage in the "Siluria": "Even then, however, the fossils which were figured as characteristic of such tilestones exhibited little else, as I showed, than species common to the Ludlow rock itself. This zoological fact, and subsequent researches in other parts of England, above all those of Professor Sedgwick in Westmoreland, where the Upper Ludlow strata are much developed, have, for eleven years, led me to classify these tilestones with the Silurian rocks, of which they form the natural summit. For, even in their range from Shropshire through Hereford and Radnorshire, into Brecon and Carmarthenshire, whether they are of red or yellow colors, they are charged with *Orthoceras bullatum*, *Chonetes* (*Leptæna*) *lata*, *Spirifer elevatus*, *Orthis lunata*, *Rhynconella nucula*, *Cucullella ovata*, *Bellerophon trilobatus*, *B. expansus*, *Trochus helicites*, *Holopella* (*Turritella*) *obsoleta*, and the minute bivalved crustacean, *Beyrichia tuberculata*. All of these are the most common fossils of the Upper Ludlow rock; although a few of them descend as low as the Caradoc sandstone" (p. 139).

From these quotations it is evident that the Tilestone was regarded by Murchison as the upper member of the Silurian

system, as he defined it in 1854 and as it occurred in his typical sections.

My attention was first attracted to the possible equivalency of the Chapman sandstone and Tilestone of Murchison, (= Downton sandstone and Ledbury shale), by noting that *Leptæna lata*, of the list in the "Silurian System" is a true Chonetes, and closely resembles some of the specimens from Chapman. On studying up the definitions and synonymy of the species, it became evident that Davidson, who identified *Leptæna lata* von Buch with *Chonetes striatella* Dalman, in doing so, was following DeKoninck. In quoting synonymy, however, he excludes Sowerby's fig. 13, of plate 5, which, as figured, presents the flatness characteristic of the species occurring in the Chapman sandstone.

The Chonetes (No. M 248), of the Chapman sandstone, agree with Hall's *C. nova scotica** in size and form, and from descriptions, I judge that the small specimens referred to *C. canadensis* by Billings,† having the proportions of *C. melonica* are identical with Hall's species *C. nova scotica*. There is also a specimen (No. M250) (I originally referred it to Orthothetes, the hinge and beak being absent) which upon examination I find presents the typical characters of *Chonetes Canadensis* Bill. so far as they are visible. Dawson states that "the new species *Chonetes nova-scotica* is very characteristic of the upper member" [of the Arisaig section].‡ Hall compared the species with "*C. cornuta* of the Clinton group of New York,"§ but the Clinton species is much smaller than even the smallest specimens in the Chapman sandstone. Billings, in describing the Chonetes of the Gaspé series, calls his more gibbous form *Chonetes melonica;* and he compares this with *C. striatella* of Dalman, but finds it distinct (p. 16). *Chonetes canadensis* Billings, differs from the description of *C. melonica* in being nearly flat. Billings remarks, however, "*Small specimens of this species* [C. canadensis] *have nearly the proportion of C. melonica, but are always nearly flat, while those of the latter are always more convex*" (p. 18).† From a study of the descriptions, it is evident that these "small specimens," referred by Billings to his species *C. canadensis*, are identical with the form described by Hall as *C. nova-scotica*—thus linking together the Chonetes of the transition beds of the Gaspé section, formation D of the Upper Arisaig of Nova Scotia, and the Chapman sandstone.

Although I find no description of the specimens referred by Sowerby to the species *Leptæna lata* von Buch, the figure so

* Canadian Nat. and Geol., v, 144, fig. 2.
† Palaeozoic Fossils, vol. ii, pt. i, p. 18.
‡ Can. Nat. and Geol., v, 137.
§ Can. Nat. and Geol., v, 145.

labelled on plate 5 certainly appears as if nearly flat. Even were this not the case (which an examination of the type specimens would demonstrate), the fact that we have in the Gaspé series both fully gibbous and flat forms, which closely resemble each other in other respects, gives reason for supposing that the British form is at least represented by these Gaspé and Maine species.

In Hall's description of the Arisaig specimens of *Chonetes nova-scotica*, it is stated, "A stronger and more elevated stria often marks the median line from beak to base of the ventral valve."* This feature is seen on several of the specimens of the Chapman sandstone, and, curiously, it is not always the central plication. In one case several plications, a little out of the center, are thus enlarged. Such a trick of variation would seem, distinctly, to indicate close phylogenetic relationship.

In the Oriskany of Albany and Schoharie Counties, in New York, a form (*C. complanatus*) quite as large as Billings' *C. canadensis*, is described by Hall. The larger forms are all from the Gaspé, Maine and Oriskany faunas at the summit of the Silurian. *Leptæna lata*, which is figured as larger than the ordinary types of Chonetes, is said to be "*one of the most characteristic shells of the Upper Ludlow*" (Sil. Syst., p. 603).

The *Bellerophons* furnish a second set of diagnostic species. In the original list of the Tilestone fauna, four species of Bellerophon are named, viz:

Bellerophon carinatus.
B. striatus.
B. trilobatus.
B. globatus.

Bellerophon trilobatus is said to be a characteristic form of the Tilestone (Sil. Syst., p. 141). This species is represented in both the Chapman sandstone and formation D of Arisaig. In "Siluria," it is stated that *B. expansus*, "*B. Murchisonæ*, *B. carinatus*, and *B. trilobatus*, generally of small size, are most abundant everywhere in the upper beds of the Ludlow rock" (p. 231). *Bellerophon carinatus* and *B. trilobatus* are both represented in the Chapman; and Honeyman reports all four species from the Upper Arisaig, Zone D (Q. J. G. S., vol. xx, p. 343).

A third diagnostic form is called "*Agnostus tuberculatus* (*Battus tuberculatus* Klöden)" by Sowerby in 1839 (Silurian System, p. 604, plate 3, fig. 17). This is *Beyrichia tuberculata* Klöden. Several specimens of this species, or a very closely related form, are recognized in the Chapman fauna. Hall

* Descriptions of New Species of Fossils from the Silurian Rocks of Nova Scotia, by James Hall. Can. Nat. and Geol., vol. v, p. 145.

described, under the name *Beyrichia pustulosa*, a species from the Zone D of Arisaig, of which he says, "This species resembles very nearly the *B. tuberculata* of Klöden, as described and figured by Mr. T. Rupert Jones."* Of this form, Murchison writes, in "Siluria," as follows, viz: "Of the latter genus, the Upper Silurian species is *B. tuberculata*. It is very abundant from the Wenlock shale to the highest Ludlow stratum, and is a good index of Upper Silurian rocks, though found sometimes in the upper division of the Caradoc" (p. 236).

In addition to these characteristic species of the Tilestone fauna in the Maine and Arisaig rocks, a majority of the forms described in Sowerby's original list of that fauna are represented by the same, or closely allied forms, in both the Chapman sandstone and Zone D (Honeyman), Arisaig; as will appear from the following table, viz:

List of representative species of the Tilestone fauna in the Chapman sandstone, Maine; and Zone D, Arisaig, Nova Scotia.

Tilestone.	*Chapman sandstone.*	*Zone D, Arisaig.*
1. Cypricardia cymbæformis	Goniophora cf. Hamiltoniæ	C. cymbæformis, cf. Nuculites (Orthonota) carinata Hall
2. Pullastra lævis	Cypricardella cf. gregarius	not reported
3. Cucullæa antiqua	Palæoneilo cf. cuneatus	Cleidophorus cuneatus
	P. cf. concentricus	C. concentricus
4. C. ovata	P. cf. elongatus	C. erectus
5. C. cawdori	P. cf. nuculiformis	C. elongatus
	P. cf. subovatus	C. semiradiatus
	and others.	C. nuculiformis
		C. subovatus
6. Arca —— ?	?	?
7. Avicula rectangularis	Pterinea rectangularis	? cf. Avicula Honeymani
8. Leptæna lata	Choneies nova scotica	C. nova-scotica H.
	C. canadensis	C. tenuistriata
9. Spirifer ptychodes (= S. elevata Dalman)	Sp. arrectus var.	Sp. regæcosta
	Sp. concinnus	Sp. subsulcatus
	Sp. cyclopterus Bill.	
	Sp. raricosta Bill.	
10. Orthis lunata	?	?
11. Terebratula nucula (= Rhynchonella)	not seen	Rhynchonella (3 species)
12. Lingula cornea	not seen	Lingula sp.
13. Natica glaucinoides	?	?
14. Trochus helicites	Pleurotomaria sp. (M 227)	?
15. Turbo Williamsi	Holopea cf. Danai	?
16. Turritella obsoleta	?	Murchisonia Arisaigensis
17. T. gregaria	Loxonema cf. planogyrata	?
18. T. conica	?	M. aciculata

* See Jones' identification of this species in the Arisaig rocks in Q. J. G. S., xxvi, p. 492.

Tilestone.	*Chapman sandstone.*	*Zone D, Arisaig.*
19. Orthoceras semipartitum	A single fragment	O. punctostriatum
20. O. ?		O. nummulara Sow.
21. O. striatum		O. ibex Sow.
22. O. tracheale		O. exornatum
23. Bellerophon carinatus	B. carinatus	B. carinatus
24. B. striatus	?	B. striatus
25. B. trilobatus	B. trilobatus	B. trilobatus
26. B. globatus	?	B. globatus
27. Tentaculites scalaris ?	B. cf. elongatus	T. distans.
28. Battus tuberculatus	Beyrichia tuberculata	B. pustulosa Hall B. equilatera

In addition to the above, *Homalonotus Knightii* König is reported from the Upper Ludlow, and also from Zone D, Arisaig; and an undetermined representative of the same genus appears among the Chapman specimens.

The presence of plants is further significant. In the Chapman sandstone a specimen of *Psilophyton*, which is probably *P. princeps*, appears in the midst of the marine fossils, giving evidence of proximity of land, and also of the transition condition leading up to the Old Red sandstone type of Devonian. "*Psilophyton* (?)" is also reported from the Upper Arisaig,* and it is the "Tilestone" of Wales (= Upper Ludlow and Downton sandstone), in which the earliest known traces of land plants appear in the Welsh succession.†

The above evidence leads directly to the conclusion that the fauna of the Chapman sandstone of Maine is the equivalent of the Tilestone fauna of Wales and of the uppermost Arisaig fauna of Nova Scotia. The latter has already been authentically identified with the "Ludlow Tilestone" by Salter, and the general fauna of the Upper Arisaig has been identified with the Lower Helderberg by all those who have studied the species.

The Nictaux iron-ore fossils indicate a somewhat younger fauna, which has been recognized by Dawson and other paleontologists as approximately equivalent to the Oriskany sandstone of the New York section.

In the Gaspé series the place of transition from the Gaspé limestones to the sandstones is very near to the horizon of the Oriskany sandstone further west. The stratigraphic and petrographic evidence in the Maine series points to the equivalency of the Chapman sandstone with the base of the Gaspé sandstone. The particular fauna of the Chapman sandstone is not known, at present, in the Gaspé series. But if this correlation with the Gaspé series be correct, the relations of the several known faunas of the Maine

* Ami. Catalogue of Silurian Fossils from Arisaig, Nova Scotia, Nova Scotia Inst. Sci., Ser. 2, vol. i, p. 185 (1892).

† H. B. Woodward, The Geology of England and Wales, pp. 104, 105 (1887).

series are in complete harmony with the known succession of the Gaspé faunas, and with such an interpretation. In that case, the Square Lake fauna of Maine would be equivalent to the fauna of the upper limestones in the Gaspé limestone series, and thus correspond with the known sequence of faunas in the Arisaig series.

Reviewing the whole evidence, the Chapman fauna must be regarded as the equivalent of the topmost fauna of the typical Welch Silurian system (= Upper Ludlow, Tilestone of Murchison, or Downton, and Ledbury formations of later authors). This places the Silurian–Devonian boundary for North America at the place where it was determined to be by deVerneuil in 1847,* classifying the Lower Helderberg formation in the Silurian system. The special Chapman fauna, I am at present inclined to think, is equivalent to the Lower Oriskany fauna, as recognized at Becrafts, and farther south in Virginia and Tennessee; but, however the precise correlation with the faunas of interior America may be settled, the place of the Chapman fauna above the general Lower Helderberg fauna is well established by the Gaspé and Arisaig sections.

New Haven, Conn., December, 1899.

* Note sur le parallélisme des Dépots Paléozoïques de l'Amérique septentrionale avec ceux de l'Europe. Bull. Soc. Géol. de France, 2d ser, t. iv.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Observations from the Astrophysical Observatory connected with the Smithsonian Institution at Washington;* by C. G. Abbot, Aid in charge.*

(1) *On the dispersion of rock salt.*—This subject has been investigated by several observers, first by Langley at Allegheny about 1886, and since then by Julius, Paschen, Rubens and Snow, and others. The object of making a further study of it was to very materially increase the accuracy of determination in the infra-red portion of the spectrum, with the hope of establishing the wave-lengths of the infra-red solar absorption lines discovered at this Observatory to a degree of accuracy corresponding with the accuracy of our knowledge of their minimum deviations in the spectrum of our great salt prism. There appeared to be strong grounds for hope of succeeding in this endeavor, in the consideration of the extraordinary facilities of the Observatory for such a research. Accordingly, the apparatus was made ready in July and August of 1898, and was actually tried in the latter part of August. Active work was, however, deferred until the latter part of December, and was done chiefly in January and February of 1899. While the method and results will be fully described in the forthcoming publication, a brief statement will be appropriate here.

The radiations of the sun were used as the source of energy up to a wave-length of 4μ, but from this point to 6.5μ (where the research was stopped, partly because the grating used was no longer applicable, and partly because further progress was of no particular interest) the radiations of an iron-gauze mantle heated in a Kitson lamp (burning vaporized petroleum) were employed. The radiations, from whichever source, fell first upon a slit 10 centimeters high, then upon a concave diffraction grating, and then upon the slit of the spectro-bolometer, which remained practically as used in taking solar bolographs. The grating apparatus being mounted according to Rowland's well-known device, radiations whose wave-lengths were multiples of each other fell upon the slit of the spectro-bolometer, and passed through to have their prismatic deviations determined. For instance, if the apparatus was adjusted so that the well-marked line of wave-length 0.5616μ in the fourth-order spectrum was found by visual observation falling at the center of the slit, then it would be certain that the radiations of the following multiples of this wave-length also fell there: 4/3, 4/2, and 4/1. The two latter would be well within the infra-red.

Suppose, now, the driving clock of the spectro-bolographic apparatus to be started, and a curve automatically produced just

*From the Report of Professor S. P. Langley, mentioned on p. 233.

as a bolograph would be. The form of this curve would be a straight line only broken by the minute accidential deflection of the galvanometer, except where the narrow bands of radiation at the above wave-lengths caused narrow, steep-sided elevations. If we suppose, still further, that either before or after this curve was made the direct sunlight was reflected upon the slit of the spectro-bolometer for several minutes, then a well-known portion of the solar spectrum energy curve would appear in its proper relative position on the same plate, and the positions of all the sharp elevations corresponding to known wave-lengths could readily be measured on the comparator with reference to determined solar absorption lines of the short bolographs. Thus the wave-lengths at as many points as desired could be determined without any circle readings whatever.

Practically, this process (somewhat altered in details) was gone through with for 38 positions between wave-lengths 0.76μ and 6.5μ; and not only once, but several times, with all the care for accuracy which could be taken. As a result, it may be said that the wave-lengths of the absorption lines in the infra-red solar spectrum discovered at this observatory can be told with an accuracy of about 3 parts in 10,000, while previous to this determination 1 part in 100 would have been all that could be claimed.

(2) *Distribution of energy from terrestrial sources.*—A number of energy curves were taken, in which the Kitson lamp, provided with mantles of various kinds, was the source. Among the mantles tried were the ordinary Welsbach (which consists of impure thorium oxide) and others composed of pure thorium oxide, iron oxide, uranium oxide, etc. The distribution of energy between different wave-lengths with these sources so different in illuminating power, is much less diversified than would be supposed, and goes strongly to show the wastefulness even of the Welsbach light as a source of illumination. For the invisible infra-red in all cases includes by far the major portion of the energy, and not the visible spectrum, as is the case with the sun and still more with phosphorescent substances. However, by the employment of a second spectroscope, or "sifting train," to exclude the stray infra-red radiations, we were able to determine the distribution of the relatively small amount of energy in the visible spectra of the various sources, and to show how far the ordinary Welsbach mantle outstripped them all for light, especially in the red, orange, and yellow. In these experiments a very considerable number (at least fifty) of absorption bands were discovered at wave-lengths beyond 4μ, which were most probably due to the gases given off by the lamp in burning, and perhaps solely to carbon dioxide.

(3) *Absorption in the solar spectrum.*—All the bolographic records, extending back to 1893, were carefully examined with regard to the changes in absorption noted in last year's report, and such changes were found to be more extensive and frequent

than had been supposed. The great decreases in absorption at Ψ and Ω were found to occur every spring, and to a lesser extent every fall; but were occasionally found in the winter also, but never in the summer. Such changes were found sometimes to go through their whole cycle in a week, and the absorption here is found to largely increase with declining sun.

The effect of water to absorb in this region was studied. Narrow cells of glass, whose absorption was known, were filled with water and placed in the path of the beam in taking bolographs of the solar spectrum. It was thus shown that "liquid" water absorbs most strongly at the particular regions where these annual variations are noticed. A fraction of a millimeter thickness of water was found enough to produce a great effect beyond the wave length 1.2μ, and 2 millimeters thickness produced almost complete absorption of the solar rays beyond 1.2μ.

(4) *Constants of prisms.*—In the course of the reduction of measures on bolographs the exact index of refraction at the A line for the salt and fluorite prisms was required. Several measurements of these quantities made at different times failing of satisfactory agreement, several interesting things came out in finding the sources of error.

Rock salt prisms have not constant angles. It was shown that with a rising temperature the faces of the prism, if at first flat, became convex, and all three angles of the prism increase, unless they be determined at the centers of the faces. After the discovery of the very appreciable value of this change with our great prisms, it was at once found that their faces, when polished flat, are considerably concave after coming to their constant temperature. This is because of the surface heating caused by the friction of the polisher. It is now the practice to leave the faces polished very slightly convex, to allow for this temperature change.

Effect of this on the accuracy of bolographs and on the determination of prism angles. — After a very considerable amount of analytical investigation it was shown that such concavity of prism faces as was present when the bolographs were taken need introduce no error of appreciable magnitude in the relative deviations of the bolographs, provided the angle of the prism was determined to within 10 seconds of arc at a point a little nearer the back of the prism than the center of the faces, and this was done in practice. However, in determining absolute quantities like the index of refraction at A, it was found necessary to be far more particular.

(5) *Measurement of refractive indices at A.*—Diaphragms just wide enough for visual resolution of A were placed symmetrically on the faces, and the prism was so placed on the prism table that exactly the same beam of light entered the diaphragm in one position of the prism as in the other, in measuring both the angle and the minimum deviation. In this way very excellent

accord was obtained between several series of measures, and the following constants were fixed for the refractive indices of rock salt and fluorite in air at 20° C. and 760 mm. pressure. Average wave-length of radiations, 0.7604μ.

For rock salt $n = 1.536818 \pm .000009$
For fluorite $n = 1.431020 \pm .000006$

(6) *Do all rock-salt prisms have the same dispersion?* We were led to believe the affirmative upon this very important question by recorded results from many prisms, but we have conclusive evidence in the following comparison of the dispersion of three salt prisms, two from Russian and one from Bavarian salt, between wave-lengths 0.4μ and 4.0μ. The results indicated the affirmative, for the differences in the refractive indices in all this range never exceeded the probable experimental error of determination. To be more precise, the results at A were as follows:

Prism R. B. I. $n = 1.536818 \pm .000009$
Prism R. B. II. $n = 1.536844 \pm .000006$
Prism S. P. L. T. $n = 1.536812 \pm .000005$

At other points the differences were of the same order of magnitude.

It follows then, as has been anticipated and elsewhere pointed out by Langley, that this most interesting crystal, whose optical application from the time of Melloni to the commencement of these observations has been chiefly qualitative as a transmitter of special radiations, can now be used quantitatively with practical convenience in the form of a 60° prism, as a standard of refraction to which all wave-lengths may be referred with the same order of precision as to the grating.

(7) *The temperature-coefficient of refractive indices for rock-salt prisms.*—Bolographs were taken at low and high constant temperatures, and from these in connection with former results the temperature coefficient for the whole range of radiations covered by our bolographs was accurately determined.

(8) *Comparison of the efficiency of the bolometer and thermopile.*—It will be recalled that the thermopile has recently been made far more delicate and efficient by improvements of Rubens, so that with him and with some others it has displaced the bolometer for radiation work. A comparison made here between one of these instruments and our bolometer, No. 20, shows the latter, though of only one-fifteenth the surface, to give twice the deflection at the galvanometer when substituted for the thermopile. The galvanometer was besides more free from "drift" and "wiggle" with the bolometer, and there was no "creep" to the deflection with it, while such "creep" lasted 5 or 10 seconds with the thermopile. The bolometer has besides the advantage that it can be made more strictly linear and far narrower than

the thermopile, and is capable of exact setting in the spectrum. To offset these advantages, the thermopile requires no battery or balancing coils, and costs but about one-thirtieth as much as the bolometer with its necessary accessories. Nevertheless, to make it equal to the bolometer as regards "wiggle" and "drift" and capacity for accurate setting, it would require a mounting at least a fourth as costly as the bolometer and its accessories. On the whole the bolometer has the advantage, except in cost.

2. *The Electro-Chemical Equivalents of Copper and Silver*;* by THEODORE W. RICHARDS, E. COLLINS and G. W. HEIMROD.—Since Faraday pointed out in 1833 that the amounts of different substances, separated in successive cells by a given current of electricity, are proportional to the chemical equivalents of the several substances, numerous attempts have been made to verify this important law with rigid accuracy. None of these attempts have been very successful, since there are so many possibilities of error, owing to "side reactions," in the determination both of the electrochemical and the strictly chemical equivalents. The two metals most convenient for the practical application of this principle are copper and silver, and it seemed likely that a careful comparative study of the copper and silver "voltameters" might therefore be both of practical and of theoretical interest. Accordingly the present investigation, which has extended over a space of four years, was undertaken to clear up, if possible, the discrepancies.

It was found, in verification of the work of Foester and Seidel, that copper dissolves in cupric sulphate with the formation of a small quantity of cuprous sulphate, which attains a definite concentration for each temperature. Unless acid is present, cuprous oxide or hydroxide is formed by hydrolysis from this sulphate. The consequence of this singular condition of equilibrium is that from the pure acidified cupric solution less copper is deposited than corresponds with the current of electricity used, because some of the copper goes into the formation of cuprous sulphate: and from the partly cuprous solutions more copper is deposited than corresponds with the current, because in this case only single charges of electricity are set free from some of the ions deposited. We are thus between Scylla and Charybdis.

Moreover, before the cupric solution is made so dilute that its solvent action becomes negligible with a given current density, the deposition of hydrogen interferes with the exact determination of the electrochemical equivalent, even before the hydrogen is actually evolved in bubbles. Hence the use of a small cathode is dangerous beyond a limit which depends upon the degree of accuracy required. With small current density an approximate correction may be made for the area of the cathode. Vanni's

* This Abstract was prepared for this Journal by one of the authors. The original paper was presented to the National Academy of Sciences in November; it is printed in full in vol. xxxv of the Proceedings of the American Academy, and in vol. xxxii of the Zeitschrift für physikalische Chemie.

method of correcting the irregularity by adjusting the amount of acid present is simply a device for replacing the copper by cuprous oxide; and although its results are not very erroneous, it must be considered scientifically unsound.

We found that, by reducing very much the temperature and by protecting the solution from the air so as to exclude this oxidizing environment, it was possible to obtain maximum and minimum results, from acidified cuprous and cupric solutions respectively, which were fairly close together. The average between these two was still much less than the amount corresponding to the silver voltameter. The obvious inference from this discrepancy was that the silver voltameter is itself erroneous, and deposits, for some reason or other, too much silver to correspond to the current.

The careful investigation of the sources of this inaccuracy, both from the study of earlier work and from our own experience, led us to conclude that the irregularities were caused by some unusual action at the anode, and hence it is obvious that by excluding this anode with the help of a *fine-grained porous cup* it was possible also to exclude the irregularities. Upon careful trial the porous cup was found to give desirably constant results, which were 0.082 per cent lower than the amounts of silver obtained with the same current from Lord Rayleigh's standard. This amount, as is indicated below, was just enough to account for the discrepancy noticed in the work upon copper. It was found in the same way, that Patterson and Guthe's method yielded a result about 0.2 per cent higher than the porous cup voltameter. Upon applying these corrections to the chief results which have been obtained for the electrochemical equivalents of silver, it was found that all of the results were fairly concordant, indicating a deposit of about 1.1172 milligrams of silver per ampere per second.

Since the electrochemical equivalent of copper upon the same basis was found to be equal to about 0.3292 milligram per ampere per second, and since the atomic weights of silver and copper and silver are respectively 107.93 and 63.604, it is clear that Faraday's Law is verified more precisely than before. For $1.1172 : 0.3292 = 2(107.93) : 63.60$.

Conversely, supposing Faraday's Law to hold rigidly, and the value 63.60 to represent the atomic weight of copper, the agreement furnishes evidence of the accuracy of the new method.

3. *Irreversible Radiation Phenomena.*—An important theoretical article on this subject has been published by Professor Max Planck. It is a study of the application of the electromagnetic theory of light to the laws of thermodynamics. The author recognizes the fact that since the phenomena of heat satisfy the second law of thermodynamics, the electromagnetic theory must also embrace this law in its generality. He discusses the phenomena of heat and light from the point of view of this theory; regarding the molecules as oscillating systems, sending out or receiving electrical waves, and he finds the necessity of enunciating electro-

dynamic laws analogous to the thermodynamic ones, for instance, laws of electrical entropy similar to that of heat entropy.

The necessity of such an extension of theory he illustrates by the following reference to spectrum analysis:

In the usual light theory, a bundle of rays of light, for instance that of the D line, is fully defined, if its plane of polarization, its color and intensity are given, together with its range of wave length. In the electrodynamic theory there is no such definiteness. Even if we take a millionth part of the visible spectrum, with a vibration-interval represented by the ratio 1 : 1,000,001; the period of the wave must be selected from all waves comprised between 510 billion and 510,000,510,000,000, that is from 510 million different vibration-periods. If the electric force is developed as a function of the time in a Fourier series, these 510 million vibration numbers will enter, for the determination of which we have only the intensity and the breadth of the spectrum of the ray. The author proceeds to develop the theory and to show the necessity of electrodynamic relations, analogous to the thermodynamic ones already recognized in the subject of heat.—*Ann. Phys.*, i, No. 1, pp. 69-122, 1900. J. T.

4. *A Radio-active Substance emitted from Thorium Compounds.*—Professor RUTHERFORD of McGill University, Montreal, has discovered that thorium compounds continuously emit radio-active particles of a certain kind which retain their radio-active powers for some time. This emanation has the power of ionizing gas and of passing through thin layers of metal and through layers of paper. He considers the question of the origin of the emanations and finds that they are not due to dust particles. They may, however, be due to vapor given off by the compounds. The evidence on this head is negative. The compounds have the remarkable property of producing radio-activity in all substances on which the emanation falls. This power lasts for several days and the radiation is of a more penetrating character than that of thorium or uranium, and thus has properties which thorium itself does not possess.—*Phil. Mag.*, Jan. 1900, pp. 1–14. J. T.

5. *Nature of White Light.*—M. E. CARVALLO believes that white light cannot be expressed by the usual formula $\epsilon^{-kt} sinht$, which denotes a damped vibration, for he finds that this gives a maximum of intensity which does not agree with the results of Langley and Mouton. Moreover when this formula is used in the theory of the grating white light results and not colored spectra. The error comes from retaining only those radiations which are sensible to the eye and in neglecting those intensities which are spread out in all azimuths.—*Comptes Rendus*, No. 2, Jan. 1900, pp. 81–82. J. T.

6. *New Electrical Condenser.*—BRADLEY has discovered a new substance which has a specific inductive capacity fifteen times greater than paraffined paper and about nine times greater than that of mica. The material is stearate of lead (stearinsaures Blei).—*Zeitshrift für Instrumentenkunde*, Dec. 1899, p. 215.

J. T.

7. *The Kinetic Theory of Gases. Elementary Treatise with Mathematical Appendices;* by Dr. OSKAR EMIL MEYER. Translated from the second revised edition by ROBERT E. BAYNES; pp. 472. London, 1899 (Longmans, Green & Co.).—The first edition of Dr. Meyer's work appeared in 1877, when the Kinetic Theory of Gases had just been fully developed. It was an admirable discussion of the subject at that time, and for the ordinary student of physics or chemistry had the great advantage of being presented in a readily intelligible form and not simply from the mathematical standpoint. This first German edition has been widely and favorably known in England and this country. Now, after the lapse of more than two decades, in which the theory has been perfected and at the same time the difficulties involved in it have been clearly shown, Dr. Meyer brings out a second edition, presenting the same subject as it stands to-day. The plan of the earlier work has been retained, the body of the volume containing the general discussion and the mathematical treatment being given in the series of appendices. This, as will be seen, at once meets the needs of all classes of readers. The work is so well known that special discussion of its contents, or comment upon the clearness of the treatment, hardly seem required. The English translator has performed important service in presenting the work to students in England and America in their own language. The translation has had the advantage of some additions and modifications suggested by Prof. Meyer, under whose eye the proofs have passed.

8. *The Rise and Development of the Liquefaction of Gases,* by WILLETT L. HARDIN, Ph.D., Harrison Senior Fellow in Chemistry in the University of Pennsylvania; pp. 250. New York, 1899 (The Macmillan Co.).—An evidence of the wide interest felt in scientific subjects at the present time is given by the fact that when a new subject is rapidly developed, it is not long before a comprehensive volume giving the main facts regarding it is available for the general public. The present volume is a case in hand, and in preparing it the author has performed a service to the many interested in the past history of this subject, in its present development and also in the possibilities for the future, a topic somewhat imaginatively treated by the public press. From the early days of Boyle and Mariotte, he passes on to the classical work of Faraday and Andrews, and then to the more recent labors of those who have proved that the so-called permanent gases have no existence, the last steps being the liquefaction and solidification of hydrogen by Dewar. This volume should be read with interest by a wide circle of readers.

9. *An Introduction to the Study of Central Station Electricity Supply,* by ALBERT GAY and C. H. YEAMAN; pp. 467. London, 1899 (Whittaker & Co.).—This excellent work is one of a series of volumes prepared expressly for electrical engineers; it gives a clear and thorough statement of the many branches of work involved in the supply of electricity from a central station.

It has the somewhat unusual merit of having been prepared by authors who are themselves engaged in practical work, and consequently fully alive to the needs of others in the same line. It is comprehensive in scope, discussing the municipal relations of the work, the practical questions of building, as well as the more special topics of systems of supply, forms of steam generators, and the electrical equipment in general. The best forms of switch-boards and regulators are described, the methods of distribution with the various mains, etc. A chapter is given to the methods of charging for electrical energy, and the price involved; also another to the analysis of cost of management in its different departments.

10. *Annalen der Physik.*—The time-honored periodical, which for more than a century under the charge of Gren, Gilbert, Poggendorff and the Wiedemanns, has done so much for the development of physics, begins its fourth series with the first number for 1900. The title has been changed in recognition of the fact that the journal is now devoted to physics exclusively, and it is for the future to be edited by Dr. Paul Drude in Leipzig. The general interests of the journal will be cared for by the following gentlemen: F. Kohlrausch, M. Planck, G. Quincke, W. C. Röntgen, E. Warburg; of these M. Planck assumes special responsibility; they will be supported by the Deutsche Physikalische Gesellschaft.

II. Geology and Mineralogy.

1. *The Geology and Physical Geography of Jamaica; Study of a Type of Antillean Development.* Based upon Surveys made for Alexander Agassiz. By Robert T. Hill. With an Appendix on some Cretaceous and Eocene Corals from Jamaica. By T. Wayland Vaughan. Bull. Mus. Comp. Zool., Harvard College, vol. xxxiv (Geological Series, vol. iv,) plates i–xli, figures 1–40, pp. 1–256, 1899.—Jamaica, as the central land-mass of the American Mediterranean region, has been chosen by Professor Agassiz for thorough geological investigation. "This central position of the island is important from geographic, biologic, and geologic points of view, and makes it a typical base of study for one interested in Antillean problems. Like a measuring gauge set up in the middle of a stream to record the rise and fall of a river, it stands in the center of the American Mediterranean,—a standard geological index of the great oscillatory changes of level which have taken place in the history of Tropical America, whose feebler amplitudes only are indicated in the perizonal continental borders." Mr. R. T. Hill having made the necessary investigation of the geology of the island, presents in this volume an exhaustive account of the present geological condition of the island. From the facts gathered, the author has drawn the following conclusions regarding the known history of the Antillean region: "The geology and configuration present

no evidence whatsoever whereby past land connections can be established between these islands and the North and South American lands in Post-Jurassic time, especially in the Tertiary, Pleistocene, or recent epochs. The configuration and conditions of these islands in Pre-Jurassic time cannot even be surmised. There are some hypothetical and biologic reasons for believing that the outer rim of the American Mediterranean constituted a partial or complete bridge between the continents in Jurassic time, and that the Panama bridge did not then exist. The first definite evidence of Antillean lands is found in the eruptive rocks of late Cretaceous time, when it is probable that there were marine volcanoes. The land débris constituting the Eocene strata throughout the islands testifies the pre-existence of extensive Cretaceous land areas. There was a profound regional subsidence in late Eocene and early Oligocene time, which submerged all but the highest tips of the Antilles, and which extended to the margins of the surrounding continents. In late Oligocene or Miocene time there was a tremendous orogenic movement which resulted in uplift, whereby many of the islands were connected with each other, and possibly an insular southern portion of Florida, but not establishing land connection with the North and South American continents. In Miocene or early Pliocene time the islands were severed by submergence into their present outlines and membership, which they have since retained with only secondary modification. In Pliocene and Pleistocene time there have been intermittent periods of elevation without serious deformation, but not sufficient to establish land connections or to restore the island to the heights and areas of Mid-Tertiary time. The Pleistocene movements, while epeirogenic, were sufficiently differential to show that they were not uniform in all parts of the area, showing great differences in amplitude within the West Indian area, and were not harmonious with those of the North American coastal plain. The irregularities of the submerged configuration of the West Indian region are orogenic, and not due to submerged continental drainage systems. The elevated coral reefs of the West Indies were formed on rising lands." The volume is beautifully illustrated with numerous heliotype pictures of the important geological features of the island. W.

2. *Maryland Geological Survey.* Volume III; by WILLIAM BULLOCK CLARK, State Geologist, plates i—xxxv, pp. 11–461, and 3–80, 1899.—This report includes, in addition to the State Geologist's account of the organization of highway investigations, chapters on the following subjects: The relations of topography, climate and geology to highway construction, by William Bullock Clark; highway legislation, and its influence on the economic development of the state, by St. George Leakin Sioussat; the present condition, the construction and repairs of roads, by Arthur Newhall Johnson; and on the qualities of good road-metals, the methods of testing them, method and ex-

pense of road improvements, and the advantages of good roads, by Harry Fielding Reid.

In the excellence of paper, illustrations, and its general make-up, this volume maintains the high standard of previous volumes. If one part may be selected for special comment, it is Part IV, on the present condition of Maryland highways, written by Arthur N. Johnson, formerly connected with the Massachusetts Highway Commission. Based upon a thorough examination of the highways of Maryland, the report presents a very complete account of their present condition and future needs. In the latter half of the article, detailed information is given regarding the roads and their problems in each county, illustrated by colored geological maps of each county, with the roads marked in their relations to the geological formations. Detailed explanations are given of the position and use of different kinds of rock for road-making purposes. The combination of pure science and practical utility is here brought to a high degree of perfection and success.

W.

3. *A Memoir on the Paleozoic Reticulate Sponges constituting the family Dictyospongidæ;* by JAMES HALL and JOHN M. CLARKE. Memoir II, New York Geological Survey, 350 pages, LXX plates. Printed 1898.—This memoir* brings together into one volume of text and plates all that is known at the present time of this most interesting family of fossil sponges. Not only have the forms occurring within the limits of the State of New York been studied and fully illustrated, but comparisons have also been made with specimens from Pennsylvania, Ohio, and Indiana, as well as from Brittany, England, and Germany. In the desire to render the memoir as complete as possible, the authors have introduced some earlier forms, the grouping of which with the Dictyospongidæ may be doubtful, especially those founded on isolated spicules.

Other species described are omitted from the scheme of classification and lack positive evidence as to relationships. In completeness of description and illustration, the memoir is all that could be desired, but it may be regretted that more is not given in regard to the development of the individual and the intimate and necessary relationships between structure, growth, and form.

It is noted that the living sponge approaching nearest to the Dictyospongidæ is the "Venus Flower Basket," *Euplectella aspergillum*. Like *Euplectella* the fossil forms were thin-walled, vase-like sponges sustained by a delicate network of siliceous spicules, but in many details they departed from this modern representative. They measured from several inches to two feet or more in height and lived in colonies on the sandy and somewhat muddy bottoms which extended at comparatively shallow depths over southern New York, Pennsylvania, Ohio, and Indiana, during the Upper Devonian and Lower Carboniferous. Their exist-

* Briefly noticed on p. 69.

ing allies are most abundant in the more quiet waters with muddy bottoms, which form the deeper parts of the continental shelves.

As it is only in the rarest instances that the minute details of the spicular network are preserved, the separation of the fossil forms into species rests mainly upon more general characteristics. For the same reason a long time elapsed before the true nature of these fossils became evident. In 1842 Conrad described *Hydnoceras* as a cephalopod and subsequently these Hexactinellids were doubtfully grouped with the Algæ. It was not until 1881, nearly forty years later, that specimens were found at Crawfordsville, Indiana, showing the individual spicules and their spongious affinities.

Considering their fragile nature, their forms are remarkably well preserved. In some instances colonies were overwhelmed by a deposit of mud, at other times they were broken loose from their moorings before burial, but in both cases perfect molds have been left, showing not only the details of form but the *general* arrangement of the spicular network.

The form, which is the most important feature for the specific differentiation and generic delimitation of these fossil sponges, is subject to variation in several directions. The simplest type, and the most primitive as well, is a slender cone, narrow at the base and open at the upper margin. This may become almost cylindrical, as in *Dictyospongia*, or may expand into a wide saucer-like shape, as in *Hyphantœnia*. The next modification in form consists in the development of longitudinal ridges, thus breaking up the vase into pyramidal or prismatic faces. This prismatic type is determined by, and depends upon, the vertical bundles of spicules.

The bases of such sponges are conical, but as growth advances they pass into four-sided forms, due to four primary spicular bundles. Finally, as these diverge, four intermediate secondary bundles assume prominence, and the sponge becomes eight-sided, which is the normal prismatic form.

The sharpness of the prismatic angles diminishes toward the upper part of large specimens and they begin to show again the smoothness characteristic of their initial growth. Another variation in form is due to ring-like contractions at intervals along the cone or pyramid, giving a crenulated longitudinal outline. This is presumably acquired by an alternating contraction and expansion of the aperture as it grows upward, but to what extent the growth is confined to the upper part, as in corals, or to what extent there is a general expansion of the entire structure, is not discussed.

The prismatic and annular modifications combined give rise at their intersections to nodes, which in some species of *Hydnoceras* are merely blunt protuberances on the surface, but in others pass into sharp-pointed swellings of considerable elevation. The

extreme of nodal development is seen in *Botryodictya*, where these prominences become pendulous lobes arranged in numerous whorls along the cylindrical body of the sponge.

Lastly there may be modifications of the body into a stalk below and an expanded cup above, and again, as in *Phragmodictya*, there may be a basal disk for attachment, with a frill about the margin, the general effect resembling a sea-anemone in basal outline.

The spicular network gives the clue to classification. The family, as now defined, falls under the subclass Silicea and the order Hexactinellida. Since the elements of the spicular bundles are not fused together, the family further belongs in Zittel's suborder Lyssacina. The specimens from New York and Pennsylvania are molds and it is extremely rare to find the individual spicules preserved, but in the examples from Crawfordsville, the spicules, which in all siliceous sponges are composed of hydrated amorphous silica, have here been altered to pyrite, and this has often escaped oxidation. The conspicuous feature of the skeletal frame is the inner meshwork surrounding the gastric cavity, which has been already alluded to in discussing the pyramidal forms. This meshwork consists of horizontal and vertical, narrow and often flattened bundles of rod-like spicules, regularly spaced and forming a pattern of squares over the entire surface. These primary squares, which may be upward of an inch in diameter, are bisected by secondary spicular bundles and these in turn are subdivided until a fine network of squares, which may be of the sixth order, is reached.

The vertical spicular bundles extend the entire length of the sponge and the horizontal ones form complete rings. The memoir does not go into the genesis of the individual spicular rods and perhaps with the character of material available nothing definite could be learned regarding it. As commonly seen, these rods are hair-like and are spoken of as diactins, though it is possible they may be tetractins in which the rays become enormously elongated, and in growing parallel and adjacent to one another form the bundles. The entire thickness of the wall is slight compared with the diameter of the vase. The interior surface is formed of the rectangular network, while the outer surface contains large, free pentactins standing opposite each intersection of the spicular bundles. Various forms of smaller modified hexactins have been noted scattered among those of normal character. The fossils sometimes show tufts of rod-like spicules protruding half an inch or more from the nodes.

The preceding notes have been based on the Devonian Dictyospongidæ. Having obtained an idea of their characteristics, it may be well, in order to bring out the progress in differentiation shown within this family, to point out the striking features of the Lower Carboniferous forms and their derivation from Devonian ancestors.

In the lowest sub-Carboniferous faunas, the Waverly and

Keokuk, this progressive differentiation is most striking, the genera departing more widely from each other than in any previous epoch. The most notable character of these faunas is the loss of the prismatic form in many genera and the assumption of flowing outlines. Many Upper Devonian species show the tendency toward this feature in the smooth upper part of the vase in old individuals. The loss of the prismatic angles is a result of equalization of growth among several of the higher orders of spicular bundles. While this tendency is an approach to the simple primitive type, peculiar modifications have taken place in other directions. In the earlier, nodose forms, the nodes were clearly determined by the intersection of primary, vertical spicular bundles and annular enlargements.

In the Lower Carboniferous genus *Cleodictya*, on the contrary, a whorl of rounded obtuse nodes persists near the base, but these are no longer determined, as formerly, by prominent spicular bundles, the entire reticulum being a uniform fine meshwork. It is an interesting instance of the persistence of a feature after the determining cause had vanished. Another noteworthy modification appearing for the first time is the checkerboard surface of *Physospongia*. In this genus, every alternate square is raised, blister-like, above the general surface of the network, and the intermediate squares are depressed an equal amount. The effect is that of a checkerboard in which the squares of one color should be raised and those of the other color sunk below the general level of the dividing lines. Although this gives a nodose appearance, it is seen to have no relation to the nodose forms of the earlier genera.

Still another line of modification is seen in *Clathrospongia*. Here the spicular bundles become horizontal and vertical plates, perpendicular to the body-wall, changing what was originally a network into a series of pigeon holes, in which primary, secondary, and tertiary partitions can still be recognized. The depth of the wall increased until it finally equalled a quarter of the radius of the vase.

It yet remains to trace the subsequent history of this ancient family of sponges and to work out their relationships with the Dictyonine Hexactinellida of later periods. Although in some respects these ancient vase-like sponges were quite ornate and showed much differentiation, their primitive character is seen in the skeletal details and general form.

The spicules were not fused together as in the majority of modern Hexactinellids, but even in the spicular bundles maintain their individuality. In the mature stages of *Euplectella* and certain other existing genera there is a terminal sieve-like plate extending across the upper part of the cup which does not show a direct derivation from the walls. In the *Dictyospongidæ*, there is no evidence of such a modified protective structure. The most specialized feature of this family is the basal disk of *Phragmodictya*. In this genus the body-wall is cylindrical and the base is

a flat cone or plate, the irregular spicular bundles of which are continued into the upright wall of the sponge. Around the edge of the base is a frill extending outward and offering a broader surface for attachment, but this also is merely an extension from the main wall. It is possible that the spicules of the Dictyospongidæ never attained the complex and striking development found in the sarcode of living Hexactinellids.

While these features of recent species are indicative of their later geological age, and although they have lost some of their primitive simplicity, it can hardly be said that they have made any positive advancement. On the contrary, when we consider the maximum size, variety of form, and abundance of species characterizing the Upper Devonian and Lower Carboniferous, it must be concluded that these periods witnessed the culmination of the Lyssacine Hexactinellida. J. R.

4. *International Congress of Geology*—The eighth session of the "Congrès géologique international" will be held in Paris during the coming August, 16–28, in connection with the Exposition Universelle. The sessions open on the 16th in the pavilion of the Exposition, and close on the 28th, but will not be continuous, several days during the period being reserved to permit the members to visit the Exposition. It is proposed to have the meetings divided into four sections:

1. General Geology and "Tectonique."
2. Stratigraphy and Paleontology.
3. Mineralogy and Petrography.
4. Applied Geology and Hydrology.

A long and attractive series of excursions is announced, each of them under able leadership; some of these, as to the Ardennes, Touraine, Brétagne, etc., will be taken before the Congress; others to the Tertiary of the Paris Basin during the sessions, and a longer series to distant points in the Alps, the Pyrénées, and elsewhere after the close of the Congress.

Members may secure hotel accommodations during their stay in Paris at reasonable rates through the agency of the Société des Voyages modernes, 1, Rue de l'Échelle, Paris. Correspondence should be addressed to the Secretary, M. Charles Barrois, Boulevard Saint Michel 62, Paris. The treasurer is M. Léon Carez; the president, M. Albert Gaudry, membre de l'Institut.

5. *Beiträge zur Geologie und Petrographie Chile's*; by F. von Wolff (Inaug. Diss. Berlin 1899, pp. 85).—The material upon which this work is based was collected by the late Dr. W. Moericke during his travels in Chili in 1896. A sketch of the general geology is given accompanied by a map upon which the petrographic localities are noted. The petrographic portion is divided into a description of the older rocks of the coastal zone, the eruptive rocks of the Cordilleran upland, the granular and porphyritic rocks of the Andean group and the later lavas of the Andean high plateau.

The Andean rocks, which consist chiefly, as might be expected, of the diorite-andesite group, are the most interesting and their

description is accompanied by several analyses which add greatly to the value of the work. L. V. P.

6. *Repertorium der mineralogischen und krystallographischen Literatur vom* d. J. Anfang 1891, bis Anfang d. J., 1897, *und General-register der Zeitschrift für Krystallographie und Mineralogie, Band XXI–XXX.* Herausgegeben und bearbeitet von E. Weinschenk und F. Grünling. I Theil. Repertorium von E. Weinschenk; pp. 354. Leipzig, 1899 (Wilhelm Engelmann). —The appearance of the first part of the third general index (vols. xxi to xxx) to Groth's Zeitschrift brings before the mind the long series of volumes, thirty and more, which mineralogists owe to the indefatigable labors of the able editor since the enterprise was inaugurated in 1877. This has been a period of great activity and important advance in mineralogy and to this end the *Zeitschrift für Krystallographie* has contributed a large part. The fact that it has given from the beginning a remarkably complete summary of all mineralogical literature makes this Repertorium by Dr. Weinschenk of great value. The second part is promised soon.

7. *Handbuch der Mineralogie;* von Dr. Carl Hintze. Erster Band. *Elemente, Sulfide, Oxyde, Haloide, Carbonate, Sulfate, Borate, Phosphate. Vierte Lieferung;* pp. 481–640. Leipzig, 1900 (Veit & Comp.).—All mineralogists will welcome another part of Hintze's Mineralogie, which forms the sixteenth Lieferung thus far published. It is devoted to the simple sulphides, the species of galena, chalcocite and sphalerite being discussed with especial fulness.

8. *Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex;* von Dr. J. L. C. Schroeder van der Kolk; pp. 48. Wiesbaden, 1900 (C. W. Kreidel).—This paper has been republished from the pages of the *Zeitschrift für analytische Chemie.* It consists chiefly of mineralogical tables in which the species are arranged according to their refractive indices, the first and longest table being divided into two parts, of which the first includes species with indices from 1·34 to 1·83: the second those with indices higher than 1·83. Those between 1·83 and 1·93 are further subdivided, as isotropic, uniaxial, and biaxial. In each case, after the name of a species, a brief statement is made in regard to its composition and prominent physical and chemical characters. A supplementary table gives the minerals arranged according to Groth's Tabellarische Uebersicht, with indices added. The introductory portion discusses the author's method of obtaining the approximate values of the indices of a given crystal or crystal fragment by immersing it successively in various solutions whose refractive power is known and noting whether its outline is marked, because of total reflection, by a more or less prominent dark (or colored) border until this finally disappears, when the indices of crystal and solution correspond.

III. Botany.

1. *Beiträge zur Physiologie der Wurzeln ;* by Aug. Rimbach. (Berichte d. Deutsch. Botan. Gesellsch., vol. xvii, Berlin, 1899, p. 18.)—The morphology and physiology of the root is a subject that has been studied comparatively little heretofore, and the author is one of the few botanists who have called attention to the fact, that roots in many cases exhibit almost as many and as significant modifications as exist in stems and leaves. Roots are often looked upon as simply "nutritive," and are generally passed by in morphological and anatomical studies; in systematic works they as well as rhizomes are as a rule neglected. It is, therefore, the more interesting to learn something about these organs, which the author has studied very carefully for several years in the laboratory and in the field. He proposes four types: nutritive-, attachment-, contractile- and storage-roots. Roots of the first type are characterized by possessing no very pronounced power of resistance, since they have no sterëids, nor are they contractile nor especially adapted to store nutritive matters. Their only function is evidently to absorb and conduct nutrition. Certain plants possess no other roots than these, e. g.: *Dentaria*, *Corydalis cava*, *Paris*, *Tulipa* and others. Such roots are generally more slender than others. The cortical parenchyma is very poorly developed and does not persist for any considerable length of time. Furthermore, they are very plastic, being able to change their direction of growth in accordance with the local surroundings,—the conditions of the soil, for instance. Not uncommonly, however, this same structure may be recognized near the apex and in the minor ramifications of roots of the other categories. As a second category are to be distinguished such forms of roots as do not store nutritive matters and are not contractile, and in which the power of absorption is so small that their only, or at least most important, function seems to consist in attaching the plant to the substratum. These roots are named "attachment-roots." They are rare and may be found, for instance, in the epiphytic *Bromeliaceæ*. Considered from an anatomical point of view, these roots are very rich in stereome, while the cortical parenchyma is relatively poorly developed and frequently collapses. There are, however, certain roots which besides a purely mechanical function, also possess power of absorption. Such modifications are especially characteristic of *Palmæ*, *Gramineæ*, *Cyclanthaceæ* and *Araceæ*, epiphytic as well as terrestrial. The contractile roots constitute the third category. Their main function lies in their power of contracting and thus drawing the shoot deeper and deeper down into the ground. These roots have very little or no sterome, but possess an enormously developed thin-walled parenchyma, which persists through a long period of the plant's life. They are especially well represented in *Scilla*, *Ornithogalum*, *Crocus*, *Gladiolus* and *Oxalis*.

The contractile power of these roots does not always have the result of drawing the shoot deeper into the ground, but may, as in *Scrophularia nodosa*, merely serve to keep the shoot in place. In such cases contractile roots assume a function that belongs properly to the true attachment-roots, which lack contractile power. Storage-roots are such roots as possess a large persistent parenchyma, in which nutritive matters are stored. Such roots often become tuberous by the excessive development of this parenchyma. They are well known in various species of *Aconitum*, *Hemerocallis*, *Orchis*, many *Melanthaceæ*, etc. Some of these roots may at the same time be contractile, as for instance in: *Succisa*, *Plantago*, *Anthericum*, *Veratrum*, etc. The author also describes various phases of the biology of the root, such as longevity, ramification, periodical development, and the occurrence of different root-systems in the same species, which include many points of interest and importance. The paper is a highly welcome contribution to our knowledge of the root, in its structure and functions, and deserves to be studied carefully. T. H.

2. *Die Keimung der Samen von Anemone apennina*; by Fr. Hildebrand. (Berichte d. Deutsch. Botan. Ges. Berlin, 1899, p. 161.)—The author describes a very singular manner of germinating, as exhibited by *Anemone apennina*. The cotyledons possess long petioles, which have grown together in their entire length and pass gradually over into an almost globular tuber, which represents the axis of the seedling; the primary root develops from the base of the tuber. So far the seedling reminds us very much of that of *Eranthis hyemalis*. But, during the first season, the author noticed that the basal part of the cotyledonary petioles attained a darker color, and that not only hairs developed, but even secondary roots; besides, an anatomical examination proved this same basal part to possess the structure of a root with only one central mestome-bundle. The seedling exhibits thus the singular case that the basal portion of the grown-together, cotyledonary petioles develops as a root, with its structure and function. During the first year the seedling develops the first proper leaf, which is green and which appears from the apex of the tuber. It might seem, at a first glance, more strange than it really is that roothairs and roots should develop from the cotyledonary petioles, yet we must remember that even petioles of various plants may be easily forced to produce roots by means of artificial culture. A close relative of this *Anemone*, *A. blanda*, does not exhibit this manner of germinating. A tuber is developed in this species and the petioles of the cotyledons grow together, but no roots or hairs develop from their bases, and the first proper leaf does not appear until the following year, while in the former species it developed contemporarily. T. H.

3. *Die Carex-vegetation des Aussertropischen Südamerika* (ausgenommen Paraguay und Südbrasilien); by Georg. Kükenthal. (Engler's Jahrb, vol. xxvii. Leipzig, 1899, p. 485.)—Sixty-

one species of *Carex* are enumerated from this part of South America, of which thirty are endemic and fifteen only known from tropical South America besides; four varieties are, moreover, not known from elsewhere, while the typical forms occur in the northern hemisphere;—*C. vulgaris* Fr. is the only cosmopolitan species among them. The systematic arrangement of these species is very interesting, and three subgenera are adopted: *Vignea*, *Vigneastra* and *Eucarex*. These are again divided into twenty sections, mostly those of Drejer, Fries and Tuckermann, while the subsections are arranged in accordance with the number and position of the spikes: monostachyous, homostachyous and heterostachyous, of which the first one is generally supposed to represent the oldest type.

The species are very carefully described in Latin, and a number of varieties are included. Synonyms are also given in connection with reference to literature, besides the habitat and geographical distribution. The author has beyond doubt been very successful in his attempt to classify this difficult genus in natural sections, similar to those suggested by Drejer as far as concerns the morphological characters, and the paper constitutes, therefore, an important basis for future research. However the morphological characters, striking as they may appear, are often very deceiving. We wish that the author had, at least to some extent, compared his morphological classification with such anatomical studies in *Carex*, of which the literature possesses such interesting and important contributions as those of Lemcke, Mazel and others. The external structure of utriculus, for instance, is often very uniform in many species, hence these are classified in one section, yet an anatomical study of this little organ reveals a number of striking divergences, which may prove useful not only in classifying the species among themselves, but also in establishing natural sections. T. H.

4. *A list of the plants of the Pribiloff Islands with notes on their distribution;* by JAMES M. MACOUN. (The Fur seals and Fur seal islands of the North Pacific Ocean. Part 3. Washington 1899, p. 559.)—A complete catalogue of all the plants that have been found on these islands since their discovery in 1786 is given in the present paper, the total number of Phanerogams amounting to 172; 3 species of *Equisetum*, 3 of *Lycopodium*, and 6 ferns besides a number of mosses, lichens and fungi, are recorded. Among the Phanerogams we notice several species as being circumpolar, for instance: *Saxifraga stellaris* var. *comosa*, *Chrysosplenium alternifolium*, *Eutrema Edwardsii*, *Hippuris vulgaris*, *Kœnigia islandica*, etc., the last being the only annual species. *Papaver Macounii*, *Cardamine umbellata*, *Chrysosplenium Beringianum*, *Primula Macounii*, *P. eximia*. *Polygonum Macounii*, *Elymus villosissimus* and *Carex Pribilovensis* are described as new, and the first six are, furthermore, figured. The paper constitutes a very important contribution to the knowledge of this flora, and it may be stated that the author has personally examined all the species included in the list. T. H.

5. *The Missouri Botanical Garden.*—The eleventh annual report, bearing date Jan. 10th, 1900, is at hand. Like its recent predecessors it contains a report of the officers of the Board of Trustees and the annual report of the Director. From these it is apparent that the assiduous care exercised by the Director has been fruitful in good results in every way. The Garden and the Arboretum continue in his charge to exert great influence, not only throughout that part of our West which has the good fortune to possess them, but throughout our whole country.

The scientific papers are: 1. A disease of Taxodium distichum, by Hermann von Schrenk. 2. Certain Agaves flowering in the Washington Garden in 1898, by J. N. Rose. 3. A revision of certain American species of Euphorbia, by J. B. S. Norton. 4. A revision of the species of Lophotocarpus of the United States; and description of a new species of Sagittaria, by Jared G. Smith. All of these are valuable papers. The first one mentioned was Dr. von Schenck's Thesis for his doctorate. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *Report of S. P. Langley, Secretary of the Smithsonian Institution, for the year ending June 30th, 1899;* pp. 81. Washington, 1899.—The report of an institution at once so active and so useful as the Smithsonian is always of interest. The various matters of administration are here discussed in detail and also the special lines in which the institution is able to promote scientific research. One of the most important of these is the work made possible through the Hodgkins fund, under the auspices of which a series of different investigations have been carried on. The development of the National Zoological Park is spoken of and also the work of the Astrophysical Observatory. A series of appendixes give further detailed statements in regard to the various subjects by the different gentlemen in charge. From the report of Mr. C. G. Abbot, in charge of the Astrophysical Observatory, we quote extensively in another place (p. 214).

2. *Report of the United States National Museum.* Part I, pp. xxvii, 1021. Washington, 1899. (Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the Institution for the year ending June 30th, 1897.)—This volume contains the report of the condition and progress of the United States National Museum to June 30th, 1897, by Charles D. Walcott, in charge. A detailed account is given of the numerous additions to the various collections and of the extensive work of exploration and investigation that has been carried on under the auspices of the Museum. Part II contains papers upon certain portions of the collections. Of these may be mentioned, one on Recent Foraminifera, by James W. Flint, pp. 249–349, illustrated by eighty plates; also

two papers interesting to mineralogists, by Wirt Tassin, one a catalogue of a series of specimens illustrating the various properties of minerals; and a second, the detailed system of classification of species adopted in the Museum. The remaining papers are upon ethnographical subjects; one of these, by J. D. McGuire, describes the pipes and smoking customs of the American aborigines; another, by Thomas Wilson, describes pre-historic arrow-points, spear-heads, and knives. Both of these are fully illustrated and will be found interesting by those at work in this department.

3. *Maryland Weather Service;* Vol. I. WILLIAM BULLOCK CLARK, Director; pp. 1–566. Baltimore, 1899 (The Johns Hopkins Press).—This first volume of a new series of reports on the Maryland Weather Service maintains the high standard set by the other Maryland scientific publications under the direction of Professor Clark. The Board of Control of the Maryland Weather Service consists of the Director; the Secretary and Treasurer, Milton Whitney, representing the Maryland Agricultural College; and the Meteorologist, F. J. Walz, detailed by the Chief of the U. S. Weather Bureau. Volunteer observers scattered throughout the twenty-three counties of the state assist in the work, reporting regularly to the meteorologist. The field laid out for investigation is very broad and gives to the weather service an unusual scope, so that valuable results may be looked for. The present volume opens with an Introduction by the Director. Part II, pp. 41–216, following is devoted to a general report on the physiography of Maryland, by Cleveland Abbe, Jr. This is an interesting discussion of the development of the important features of the different provinces in the State, the Coastal Plain, the Piedmont Plateau, and the Appalachian Province. Part III, pp. 219 to 548, contains the Report on the Meteorology of Maryland by Cleveland Abbe, F. J. Walz and O. L. Fassig, which has already been noticed in this Journal (p. 81).

4. *The International Monthly.*—This new periodical, "A Magazine of Contemporary Thought," has recently been inaugurated. It is published at Burlington, Vermont, by the Macmillan Company (of New York), and is under the editorship of Frederick A. Richardson; the advisory board includes a large number of well-known names at home and abroad in a wide range of departments. The two numbers already issued show an active treatment of live subjects; two of the articles included are of scientific character.

5. *Histoire des Mathématiques;* by JACQUES BOYER. Pp. 256, with 19 portraits and 7 facsimiles of manuscript. Paris, 1900 (G. Carré et C. Naud). This work forms a volume of the *Bibliothèque de la Revue Générale des Sciences*, and presents in brief outline the history of Mathematics from Ahmes to Lobatchewsky. Where so much is comprehended the compression is necessarily great. Thus China, Babylon, Chaldea and Eygpt occupy but seven pages. But by help of a vigorous style and judicious selection with the avoidance of technicalities, the

author has produced a volume that can be read with much profit and without fatigue by any cultivated person.

6. *The Earth Measured.* By a member of the Chicago Mathematical Society. Pp. 40.—A useful collection of the results of geodetic measurements with related quantities for Sun, Moon and Jupiter.

7. *Leitfaden für den Unterricht in der anorganischen Chemie.* Didaktisch bearbeitet von Dr. Joachim Sperber. Erster Teil. 8vo, pp. vi, 120. Zürich, 1899. (E. Speidel.) Mks, 2.40.—The first part of a simple laboratory manual used by the author with his own classes and serving as a guide to the more elementary physical experiments. These are well described and fully illustrated; in some cases with full page cuts. G. F. B.

8. *La Tension de dissociation avant H. Sainte Claire Deville.* Introduction par P. Duhem à une memoire *De l'influence de la pression sur les actions chimiques.* Par Georges Aimé (1837). 8vo, pp. 32, Paris, 1899. (A. Herrmann.)—This brochure is intended to clear up a historic point in science. The thesis of Aimé printed in 1837, as Duhem states in his introduction, seems to show clearly that this physicist had conceived the idea of a dissociation tension thirty years before it was developed by Debray and Deville. G. F. B.

Obituary.

Professor Henry Allen Hazen, of the Forecast Division of the U. S. Weather Bureau, died suddenly at Washington on January 23d, as the result of an accident. He was born January 12, 1849, in Sirur, India, the son of missionaries of the Congregational church. He came to this country when ten years old and was educated at St. Johnsbury, Vermont, and at Dartmouth College, where he was graduated in 1871. After this for four years he was instructor in drawing in the Sheffield Scientific School at New Haven, and subsequently was assistant in meteorology and physics under Professor Elias Loomis, being associated with him in meteorological researches and the preparation of his "Contributions to Meteorology." In May, 1881, he became connected with the Signal Service and took a prominent part in the development of the scientific work of the Bureau in accordance with the plans of the chief signal officer, Gen. William B. Hazen. Besides the work specially belonging to him, as the deduction of altitudes by railroad levels, the study of the psychrometer, the proper exposure of thermometers, the study of thunder storms, etc., he devoted himself also to such subjects as barometric hypsometry and the reduction to sea level, the testing of anemometers, the study of tornadoes and the theories of cyclones, atmospheric electricity, balloon ascensions, the influence of sun spots and the moon, etc. During the administration of General Greely, he became a junior professor at a higher salary and was assigned to official duties of broader aspect. He frequently took his turn as forecast official

and as editor of the Monthly Weather Review, also acting as assistant in the Records Division. In July, 1891, on the transfer of the service to the Department of Agriculture he was appointed one of the professors of meteorology in the Weather Bureau, where he was at once assigned to regular and congenial duties in the Forecast Division.

His name is connected with the "Hazen Thermometer Shelter," which being shown to be better than the large close double louver formerly used, was adopted by the Bureau in 1885 and still remains in use. His experimental work with the sling psychrometer and dew-point apparatus was executed with great care and refinement, but the resulting psychrometer formula differs from those in current use in that it rejects the important term depending on the barometric pressure. Among his larger publications were "The Reduction of Air Pressure to Sea-level" and "The Climate of Chicago." In addition to his official work in the Weather Bureau, he was a frequent contributor to meteorological and other scientific journals. He was one of the supporters of "Science" during the years 1882–89, and of "The American Meteorological Journal," 1884–96. This Journal, between 1881 and 1887, contained a number of papers by him. He also published, independently, works entitled "Meteorological Tables" and "The Tornado."

Professor Hazen was a man of strong convictions and thorough sincerity; he had an indomitable will, abundant energy and immense powers of work. His tenacity of purpose, independence and strength of feeling may have made him at times appear obstinate in adhering to his own position as against those who held different views, but his character was true and his amiable and lovable disposition he showed to those most closely associated with him. His sudden death is a great loss not only to his personal friends, but to the Department which he served so faithfully.

Dr. Hanns Bruno Geinitz, the veteran German geologist, died at Dresden on January 28th in his eighty-sixth year. Half a century has passed since he was made (1850) Professor of Mineralogy and Geognosy at the Polytechnic School in Dresden; a little earlier (1846) he was placed in charge of the Dresden Mineralogical Museum, of which he later (1857) became Director. To these duties he devoted himself with great energy, but in addition he was ever active, nearly to the close of his long life, in original investigations in geology and paleontology, and the list of his publications includes many and valuable papers; the first of these bears the date of 1839. He was a man of charming personality, alike respected by his scientific colleagues and beloved by his personal friends.

Professor David E. Hughes, F.R.S., the English physicist, well known for his invention of a widely-used type-printing telegraph system, also for his work in connection with the microphone, induction balance and other physical instruments, died on January 22d at the age of sixty-eight years.

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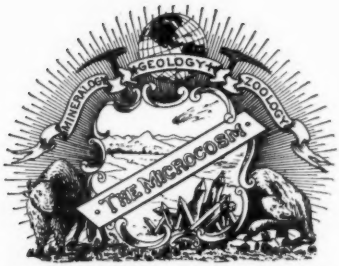

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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. I. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

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